DEVELOPMENT OF POLLUTION CONTROL CRITERIA

for

INTEGRATED IRON AND STEEL PRODUCTION

VOLUME 2

BACKGROUND REPORT

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Volume 2 Background Report

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PREFACE

In support of the pre-feasibility study conducted jointly by the Province of British Columbia and the China Steel Corporation of Taiwan, the B.C. Ministry of Environment formed the B.C. Steel Task Force to develop pollution control criteria for a proposed integrated steel mill.

The recommended criteria are draft discharge criteria developed on the basis of a detailed assessment of the best available discharge technology and the state-of-the-art steel-making processes. The starting point for assessment of the environmental protection measures is the best available technology. Eventually, factors such as environmental quality and economics are to be considered to set the site-specific conditions. These criteria are guidelines and as such generally not binding until they are applied to individual permits. They are also always to be seen as provisional, to be adjusted in accordance with technical developments and further knowledge of environmental impacts. The draft criteria document has been prepared in a very short time frame, which included a peer-review by a team of international experts in a Workshop.

This document may warrant some editorial improvements. Hopefully, it contains the basic material which will be useful for the initial site evaluation and for any subsequent feasibility and environmental studies for an integrated steel mill.

B.B. Manna
Chairman
B.C. Steel Task Force

1.0 INTRODUCTION

1.1 Objectives of Study

The study was commissioned by the Ministry of Environment of British Columbia on behalf of the British Columbia Steel Task Force to develop proposed pollution control criteria for integrated iron and steel production.

The objective was to develop pollution control criteria that would be based on the most advanced production processes and pollution control technology that would meet the majority of the pollution control concerns for such a plant and identify pollution problems that would still exist.

1.2 Background

The British Columbia Ministry of Environment does not have pollution control criteria for integrated iron and steel production. British Columbia is being considered as a site for an integrated iron and steel project. In order to be prepared for the selection of British Columbia for the site of this or a similar plant, the Ministry of Environment commissioned this project to develop pollution control criteria for an integrated iron and steel plant.

1.3 Methodology

The methodology used in preparing this report consists of three phases:

1. Information gathering,
2. Report preparation, and
3. Report review and finalization.

1. Information gathering:

The objectives and boundaries of the study were finalized with the Ministry of Environment and the Steel Task Force. The material collected by the Ministry of Environment and Task Force members was reviewed. A consultation was held with the Ministry of Environment librarian to provide advice and assistance in setting up the Ministry's information gathering and cataloguing process.

Information was gathered from sources including:

- Environmental Protection Agency (EPA) of the US
- Environment Canada
- Industry, Science and Technology Canada
- Ministry of Environment of Ontario
- Canadian steel companies
- Iron and steel associations
- Energy, Mines and Resources
- NRC - CISTI
- Technical and trade journals
- Suppliers to the steel industry

Plant visits and discussions were also made to Stelco, Nanticoke, and Dofasco, Hamilton, and discussions were held with Ministry of Environment of Ontario.

Information in the form of pollution control regulations and permits, technical reports, trade and technical articles, monitoring information and supplier literature were obtained and reviewed.

2. Report Preparation:

The report was prepared using the experience and knowledge of the consultant, the information gathered and discussions with experts. The report is structured to provide a basic overview of steel plant processing, including new process technology, an overview of the pollution generated by the various processes, an analysis of the pollution control technology applied to steel production and the resulting residual pollution. The pollution control criteria were developed based on this information and the development of model production and pollution control processes.

3. Report Review and Finalization:

An initial draft of part of the report was reviewed by the Task Force and comments and guidance was provided by the Task Force members. Following this review, the draft report was prepared for the Work Shop review. Based on the comments of the Work Shop the report was finalized.

1.4 Integrated Iron and Steel Plant

An integrated iron and steel plant processes raw materials into semi-finished or finished steel products for use as raw materials in other manufacturing processes. The basic production processes are iron making, steel making, hot forming and cold forming and are briefly outlined below and described in detail in Section 2.0.

Figure 1.1 shows the principal process steps involved in converting raw materials into the major product forms (semi-finished or finished).

Iron Making:

Iron ore is usually up-graded, at the mine site or elsewhere, by removing some of the impurities and is then smelted in a blast furnace to produce molten iron. Other raw materials such as lime or limestone are used in the process to remove the balance of the impurities. Coke, made from coal in coke ovens, is used as a reductant in the blast furnace to remove the oxygen from the iron ore.

Steel Making:

Steel is usually produced by one of two processes. The most widely used for integrated steel plants is the basic oxygen process where oxygen is blown into the molten iron to produce molten steel. The second process is the melting of steel scrap and, in some cases pre-reduced iron ore, in an electric arc furnace. The molten steel is usually cast to the appropriate shape in a continuous casting machine.

Hot Forming:

The hot steel is formed into an intermediate or semi-finished product such as plate, strip or structural shapes by passing the steel through one or more rolling mills.

STEELMAKING

FROM RAW MATERIALS TO FINISHED MILL PRODUCTS
(EXCLUDING COATED PRODUCTS)

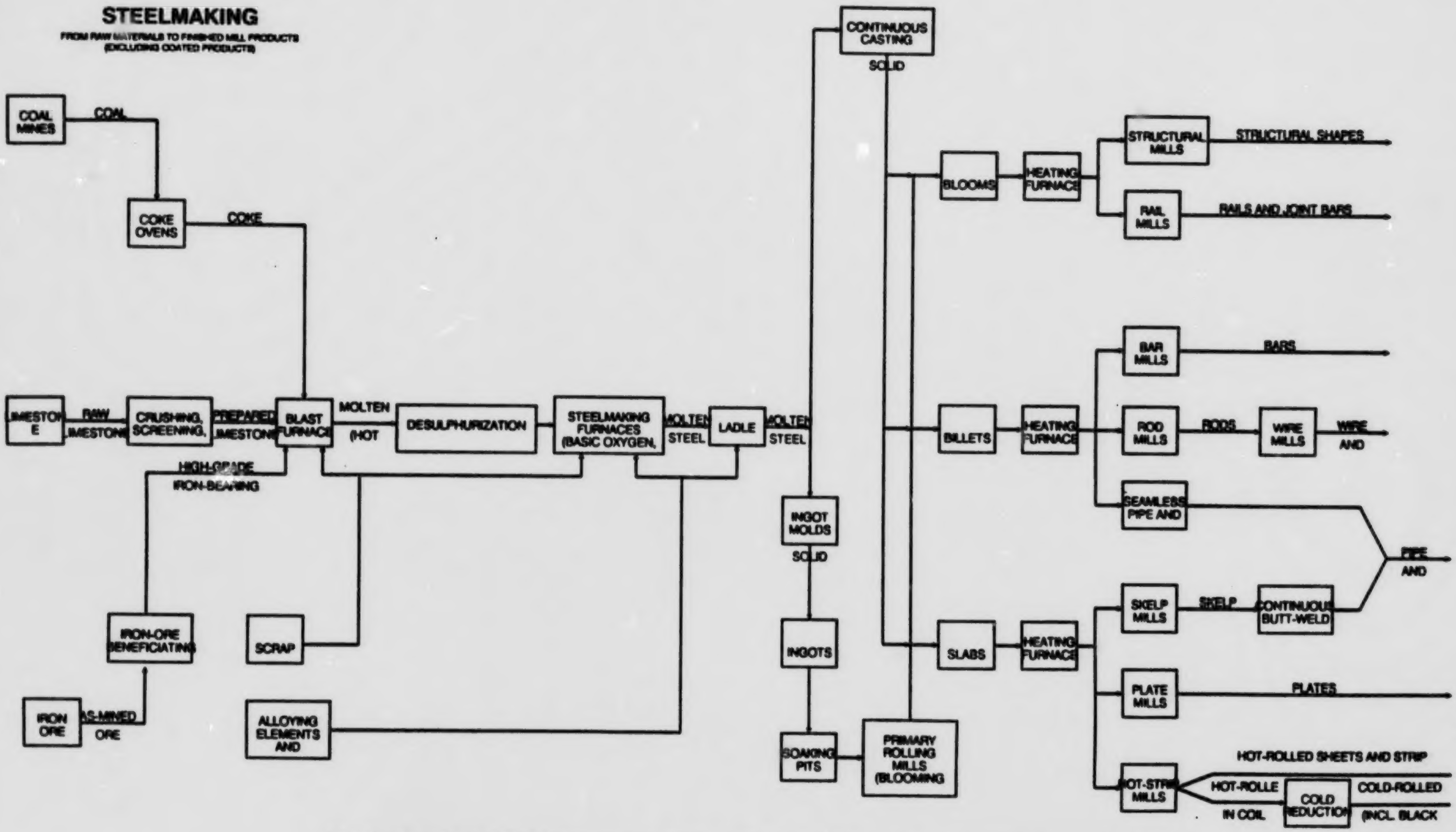

COAL MINES
COAL
COKE OVENS
COKE
LIMESTONE
RAW LIMESTONE
CRUSHING, SCREENING,
PREPARED LIMESTONE
BLAST FURNACE
MOLTEN (HOT
DESULPHURIZATION
STEELMAKING FURNACES (BASIC OXYGEN,
MOLTEN STEEL
LADLE
MOLTEN STEEL
HIGH-GRADE IRON-BEARING
IRON-ORE BENEFICIATING
IRON ORE
AS-MINED ORE
SCRAP
ALLOYING ELEMENTS AND
CONTINUOUS CASTING
SOLID
INGOT MOLDS
SOLID
INGOTS
SOAKING PITS
PRIMARY ROLLING MILLS (BLOOMING
BLOOMS
BILLETS
SLABS
HEATING FURNACE
HEATING FURNACE
HEATING FURNACE
STRUCTURAL MILLS
STRUCTURAL SHAPES
RAIL MILLS
RAILS AND JOINT BARS
BAR MILLS
BARS
ROD MILLS
RODS
WIRE MILLS
WIRE AND
SEAMLESS PIPE AND
SKELP MILLS
SKELP
CONTINUOUS BUTT-WELD
PIPE AND
PLATE MILLS
PLATES
HOT-STRIP MILLS
HOT-ROLLED SHEETS AND STRIP
HOT-ROLLE IN COIL
COLD REDUCTION
COLD-ROLLED (INCL. BLACK

Fig. 1.1 Flow diagram showing the principal process steps involved in converting raw materials into the major product forms, excluding coated products.

Cold Forming:

The material produced by hot forming is further processed to final form or finished product. These processes include cold rolling to form the desired shape, annealing, acid pickling to remove scale and surface imperfections and coating such galvanizing.

Pollution and Pollution Control.

Section 3.0 describes and quantifies the pollution arising from the various production processes and Section 4.0 describes the pollution control technology used for the various production processes and the degree of pollution control that can be achieved.

The pollutant control criteria for an integrated iron and steel plant are provided in Section 5.0.

Inherently, an integrated iron and steel plant generates significant quantities of pollutants partly because of the nature of the production processes and partly due to the large size of the plant and the large quantities of materials that are handled and processed. While pollution control technology can significantly reduce the pollution level, careful attention to process selection, process and equipment design, materials handling and plant layout can further reduce the residual pollution.

Research leading to the development of new low-polluting processes, energy conservation measures and elimination of processes that are difficult to control is on-going. One of the key objectives of this research is to change the steel plant processing from the present **batch production methods** to **continuous production methods** that are inherently less polluting and are more amenable to pollution control.

2.0 PRODUCTION PROCESSES

2.1 Iron Making

2.1.1 Raw Material Handling and Storage

The major raw materials for iron making are metallurgical grade coal for coke production, coal for blast furnace injection, iron containing material (iron ore, sinter, pellets, mill scale) and fluxes such as limestone, calcined lime and dolomite.

The raw materials used per day (per year), based on a modern steel plant with various annual production capacities of crude steel per year using pre-reduced iron pellets, no coal injection in the blast furnace and 30% scrap charge in the steel-making furnace, are shown in Table 2.1.1:

TABLE 2.1.1 RAW MATERIAL QUANTITIES FOR VARIOUS PRODUCTION CAPACITIES

Material	Capacity in millions of tonnes of crude steel per year (tonnes per day)		
	3	4	6
Pre-fluxed pellets	3.66 10,200	4.88 13,600	7.32 20,400
Coal	1.53 4,240	2.04 5,660	3.06 8,490

The mode of transportation depends on where the iron-making plant is situated (ie. inland or on tidewater) and where the material source is located. The materials may be transported by train (usually unit trains because of the large tonnage involved), by ship from offshore or, in the case of some of the fluxes which may be sourced close to the plant, by truck.

In the case of rail transport, most material is transported in hopper cars. These may be bottom dumping, in which case the material flows out the bottom of the car into a hopper, or top dumping, in which case the car is rotated in a rotary car dumper and the material flows out of the top of the car into a hopper. The material is then transported by conveyor belt to stockpiles. Fluxes and similar materials are usually transported in sealed cars with pneumatic unloading.

In the case of water transport, the material is transported in either self-unloading ships or bulk carriers. The self-unloading ships have a conveyor running along the keel of the boat and the material flows from the individual holds to this conveyor which discharges onto a separate conveyor for transport to shore. The material is then transported to stockpiles by conveyor or, if the plant is not sited on tidewater, by rail car. Bulk carriers are usually unloaded by ore bridges which lower a clamshell bucket into the ship's hold and then raise the clamshell and transfer the material to a conveyor for transfer to the stockpile.

The coal is usually reclaimed from the stockpile by heavy-duty, mobile materials handling equipment such as scrapers and front end loaders. This equipment is also often used to move the coal from the dock side or railcar unloading station to the stockpile.

The iron-bearing material is reclaimed from the stockpile by the stacker-reclaimer or by mobile materials handling equipment.

2.1.2 Agglomeration

The primary purpose of agglomeration is to improve the permeability and gas-solid contact of the charge material in the blast furnace. This reduces blast furnace coke rates and increases the rate of reduction. Secondary considerations are to lessen the amount of fine material from finely ground iron ores blown out of the blast furnace into the gas recovery system and to recycle fine iron-bearing materials, including coke fines, iron fines and mill scale that are generated by the production processes.

The blast furnace is a counter-current gas-solid reactor in which the solid charge materials move downward while the hot reducing gases flow upward. The best possible contact between the solids and the reducing gas is obtained with a permeable burden, which permits not only a high rate of gas flow but also a uniform gas flow with a minimum of channelling of the gas.

A good agglomerate for blast furnace use should contain 60 percent or more of iron, a minimum of undesirable constituents, a minimum of material less than six mm in size and a minimum of material larger than 25 mm. In addition, the agglomerate must be able to withstand the high temperature and the degradation forces within the furnace without slumping or decrepitating. The agglomerate should also be reasonably reducible so that it can reduce at a satisfactorily high rate in the blast furnace.

Sintering and pelletizing are the two types of agglomerating processes in commercial use to produce agglomerate for the blast furnace.

2.1.2.1 Pelletizing

In general, the pelletizing process is desirable for agglomeration of finely divided iron ore concentrates because they are normally of such small size that they will form into a green ball with little difficulty. This process is usually carried out at or near the mine site.

A small amount of bentonite is mixed with the finely ground iron concentrate as a binder and the mixture, with a moisture content of 9 to 12 percent, is 'balled', using a balling drum or disc pelletizer. The green balls are pre-heated to about 1040 °C and then heated to about 1310 °C for the final high-temperature sintering (induration) in a travelling grate or grate-kiln system.

Since one of the advantages of the pellets is their ability to withstand the rigours of long transportation distances without significant degradation, pelletizing plants are seldom located at the steel plant.

2.1.2.2 Sintering

The flexibility of the sintering process permits conversion of a variety of materials - including naturally fine ores and ore fines from screening operations, flue dust, ore concentrates and other finely divided iron-bearing material - into a clinker-like aggregate that is well suited to use in the blast furnace. The continuous sintering process is carried out on a travelling grate that conveys a bed of finely divided iron-bearing material intimately mixed with approximately five percent of a finely divided fuel such as coke breeze or anthracite. Near the feed end of the grate the bed is ignited on the surface by gas burners and, as the mixture moves along on the travelling grate, air is pulled down through the mixture to burn the fuel by down-draft combustion.

As the grates move continuously over the wind-boxes toward the discharge end of the strand, the combustion front in the bed moves progressively downward. This creates sufficient heat and temperature (about 1300 to 1480 °C) to sinter the fine ore particles into porous clinkers.

The sinter is cooled to below 150 °C in sinter coolers, such as the rotary-type and shaft-type, in conjunction with either an air or water quench.

The sinter is then crushed to minus 25 mm and screened to remove the fines, which are recycled to the feed end of the sinter machine. If a sinter plant is located adjacent to a steel plant, some of the flue dusts generated within the steel plant can be part of the feed material.

One new sinter plant development modifies the on-strand cooling to increase heat recuperation, sinter quality and dust collection. Another development is to increase the quantity and variety of steel plant iron-bearing materials that are sintered. This is especially true for iron-bearing metals containing low-temperature melting metal oxides and alkali materials.

2.1.3 Coke Production

2.1.3.1 Introduction

Coke, the residue produced by heating coal to a high temperature in the absence of air, is the reducing agent that is best suited for the economical production of iron.

When a metallurgical grade (coking) coal is heated to high temperatures in the absence of air, the complex organic molecules break down to yield gases, together with liquid and solid organic compounds of lower molecular weight and a relatively non-volatile carbonaceous residue (coke). The physical properties of metallurgical coke as well as its composition depend largely upon the coal used, the time duration of carbonization and the temperature of carbonization. Typical coking cycles for wet-coal charged batteries range from 16 to 18 hours and the final carbonization temperature ranges from 1,000 °C to 1,100 °C. Not all coals will form coke and not all coking coals will produce coke with the characteristics demanded by large, modern blast furnaces. Therefore, coals with different characteristics and composition are blended to produce a coke suitable for the specific blast furnace being operated.

The objective of the metallurgical coke production is to obtain the highest possible yield of suitable coke from a given coal, ie. to fix as much of the carbon in the coal as possible in the coke, while gas, tar and chemicals are considered as by-products. An integrated iron and steel plant with a coke plant with by-product recovery units is more cost-effective.

During carbonization from 20 to 35 percent by weight of the initial charge of coal is evolved as a mixture of gases and vapours which pass from the ovens into the collecting mains and are processed in the by-products plant.

Typical North American coke oven practice yields the approximate proportions of coke and coal chemicals shown in Table 2.1.3.1. The precise proportions depend on the blend of coals used and the specific operating practice.

TABLE 2.1.3.1 TYPICAL COKE AND COAL CHEMICAL YIELDS

Product	Per Tonne of Coal
Blast-Furnace Coke	600-800 kg
Coke Breeze	50-100 kg
Coke-Oven Gas	295-360 m^3
Tar	30-45 litres
Ammonium Sulphate	10-14 kg
Ammonia Liquor	55-135 litres
Light Oil	9.5-15 litres

Source: The Making, Shaping and Treating of Steel, 10th Edition, Association of Iron and Steel Engineers

The coke-oven gas contains fixed gases including hydrogen, methane, ethane, carbon monoxide, carbon dioxide, reduced sulphur compounds (including hydrogen sulphide), ammonia, oxygen, nitrogen, illuminants such as ethylene, butylene and acetylene and other trace hydrocarbon-based gases. Note that the composition of the gas will vary according to the coal used. A typical coke oven gas composition and its properties are contained in Table 2.1.3.2. The ammonia liquor (primarily the water coming from the gas) is an aqueous solution of ammonium salts and other dissolved chemicals. The tar is the organic matter that separates by condensation from the coke-oven gas and is a black, viscous liquid a little heavier than water. It contains creosote, oil, pyridine, tar acids, naphthalene, anthracene and pitch. The light oil is a clear, yellow-brown oil somewhat lighter than water and contains chemicals including benzene, toluene, xylene and solvent napthas. Coke breeze is the fine portion of the coke remaining after screening.

TABLE 2.1.3.2 TYPICAL COKE OVEN GAS COMPOSITION AND PROPERTIES

Gas Composition	Percent by Volume (1)
CO_2	1.4
H_2S	0.6
O_2	0.4
CO	5.6
H_2	55.4
CH_4	28.4
C_2H_4	2.5
C_2H_6	0.8
Illuminants	0.6
Total	100.0
Property	
M^3 of air required for combustion	4.83
Specific gravity	0.44
Heating value per unit volume of gas:	
Gross	22,550 kJ/m^3
Net	20,190 kJ/m^3
Theoretical flame temperature (no excess air)	1988 °C

NOTE: (1) All volumes at 0 °C and 101.325 kPa

Source: The Making, Shaping and Treating of Steel, 10th Edition, Association of Iron and Steel Engineers

2.1.3.2 Preparation of Coal Charge for By-Product Ovens

After unloading (Section 2.1.1) the coal may be blended by piling the various coals in layers on stockpiles. It is usually reclaimed from the stockpiles by mobile equipment.

Coal received from the mine is sometimes run-of-the-mine and varies in size. The reclaimed coal is crushed in a primary crusher, moved to the blending bins, screened, if necessary, and pulverized.

For bulk density control a small amount of oil is added to the coal, usually before the pulverizer, and the coal is then loaded into the oven head bins. As a means of re-using the coke breeze it is often added to the coal as well.

2.1.3.3 General Design of Modern By-Product Coke Ovens

The by-product coking process involves the use of retort ovens. These ovens consist of three main parts - the coking chambers, the heating flues and the regenerative chambers - all constructed of refractory brick. Coke-oven batteries consist of 30 to over 100 ovens. The ovens are designed with three or four openings in the top and a removable door at each end. The coal is charged through the openings in the top of the oven and, after becoming coke, is pushed out of the oven by a power-driven ram. The coke-oven gas is removed from the oven through a refractory lined pipe (standpipe) and a cast iron elbow (goose-neck) which connects to the collector main and transports the gas to the by-product plant for treatment. Most modern ovens are constructed with a collector main at both ends of the oven. Typical coke-oven dimensions are contained in Table 2.1.3.3. A simplified block flow diagram of a by-product coke oven plant is shown in Figure 2.1.3.1.

TABLE 2.1.3.3 TYPICAL COKE OVEN DIMENSIONS

Size	Height (m)	Width (m)	Length (m)	Coal Capacity (tonnes)
4-metre	4	.45	12.5 - 13	14.5 - 16.5
5-metre	5	.46	14 - 15.5	23.5 - 25.5
6-metre	6	.46	15.5 plus	29 - 33.5

Source: The Making, Shaping and Treating of Steel, 10th Edition

Most new ovens are the 6-metre size or larger.

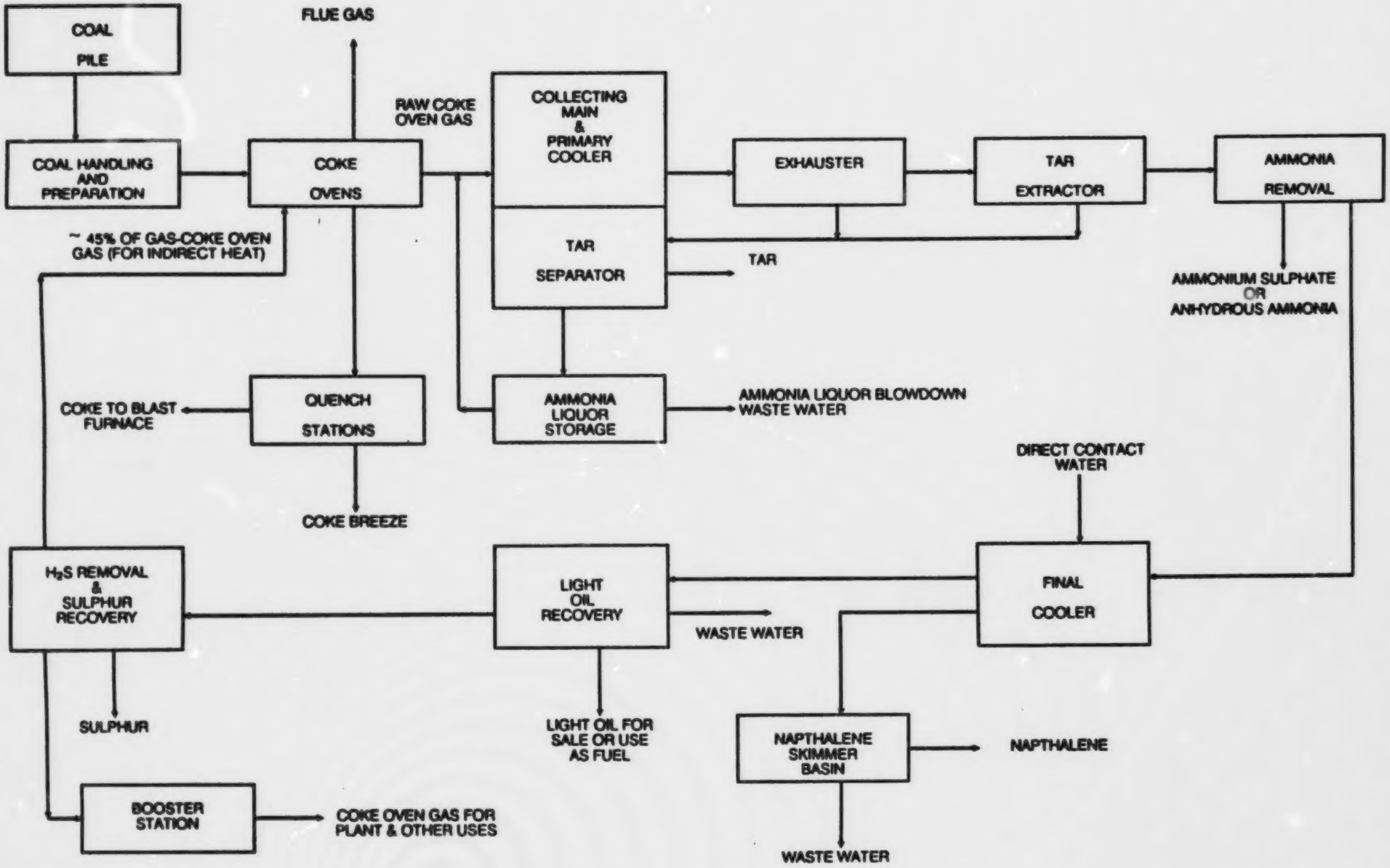

COAL PILE
FLUE GAS
COAL HANDLING AND PREPARATION
COKE OVENS
RAW COKE OVEN GAS
COLLECTING MAIN & PRIMARY COOLER
EXHAUSTER
TAR EXTRACTOR
AMMONIA REMOVAL
~ 45% OF GAS-COKE OVEN GAS (FOR INDIRECT HEAT)
TAR SEPARATOR
TAR
AMMONIUM SULPHATE OR ANHYDROUS AMMONIA
COKE TO BLAST FURNACE
QUENCH STATIONS
AMMONIA LIQUOR STORAGE
AMMONIA LIQUOR BLOWDOWN WASTE WATER
DIRECT CONTACT WATER
COKE BREEZE
H₂S REMOVAL & SULPHUR RECOVERY
LIGHT OIL RECOVERY
WASTE WATER
FINAL COOLER
SULPHUR
LIGHT OIL FOR SALE OR USE AS FUEL
NAPTHALENE SKIMMER BASIN
NAPTHALENE
BOOSTER STATION
COKE OVEN GAS FOR PLANT & OTHER USES
WASTE WATER

Figure: 2.1.3.1 SIMPLIFIED BLOCK FLOW DIAGRAM OF A BY-PRODUCT COKE OVEN PLANT

2.1.3.4 Oven Charging

Charging of the coal into the coke ovens is accomplished by a mobile machine called a larry car, which travels on rails located on the top of the ovens. The larry car has three or four hoppers, one for each hole, which are filled with coal from the head bins for transport to the oven that is to be charged. The oven lids that seal the charging holes in the roof are removed, the larry car is positioned over the holes, the larry car coal chutes are lowered to seal the charging holes and the coal charging commences with the coal being discharged into the oven by a mechanical feeder. Sequential charging, one hopper at a time, is usually practised. During the latter part of the charging cycle a leveller bar is inserted into the oven, just below the roof, to level the coal and ensure that there is an adequate gas passage. The larry car coal chutes are retracted, the lids are replaced and the larry car returns to the head bin for another charge. The charging cycle usually takes three to five minutes.

In some coke oven plants, the coal is preheated prior to charging. Waste heat from other coke plant operations is usually used to preheat the coal but gaseous fuel may also be used. The charging of preheated coal usually generates more dust since all moisture has been removed from the coal. Because of the greater quantities of dust generated and the increased fluidity of the pre-heated coal, charging is generally carried out by an enclosed system such as pipeline charging.

2.1.3.5 Coking Cycle

Heating is carried out by the combustion of a fuel (usually a mixture of coke oven gas and blast furnace gas) in flues built into the walls between the ovens. The coal is indirectly heated to about 1000 to 1100 ° C over a period of time and at a rate that depends on the characteristics of the end product.

Metallurgical coke is generally heated at a rate of 25 to 30 mm/h for a total time of 16 to 18 hours. During the heating cycle the oven is sealed and maintained at a slight positive pressure to prevent air infiltration. The gases which evolve from the coking process are drawn off the standpipes and collector mains. After the charge is fully coked, it is pushed out of the oven.

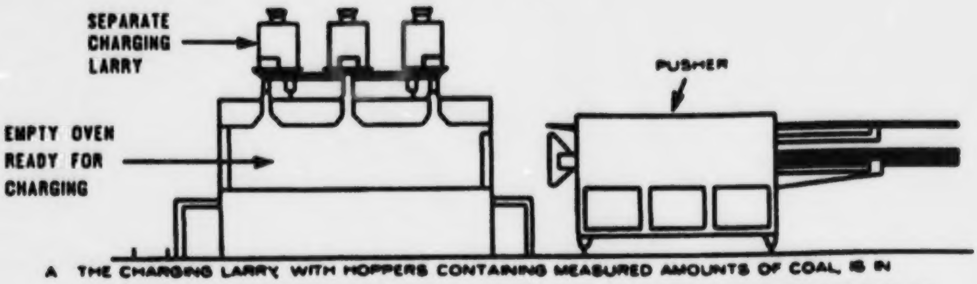
2.1.3.6 Pushing Operation

The pushing machine runs on rails along the coal side of the oven battery. The oven door is removed mechanically by the pushing machine and the pushing ram is aligned inside the door jambs. On the coke side of the battery the door machine mechanically removes the oven door and positions a coke guide against the door jambs. At the same time the quench car is positioned below and directly in front of the coke side door. The pushing machine ram pushes the hot coke out of the oven through the coke guide and into the quench car.

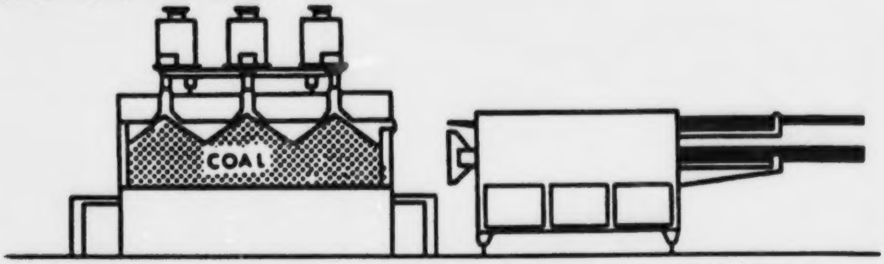
Once all the coke has entered the quench car, the pusher ram is retracted and machinery on the pushing machine and the door machine clean the door jambs and door sealing edges, repositions the doors and lock the doors in place. The levelling bar referred to in the charging operation is part of the pushing machine. The sequence of operations involved in the charging, levelling and pushing of a by-product coke oven is shown schematically in Figure 2.1.3.2.

2.1.3.7 Quenching

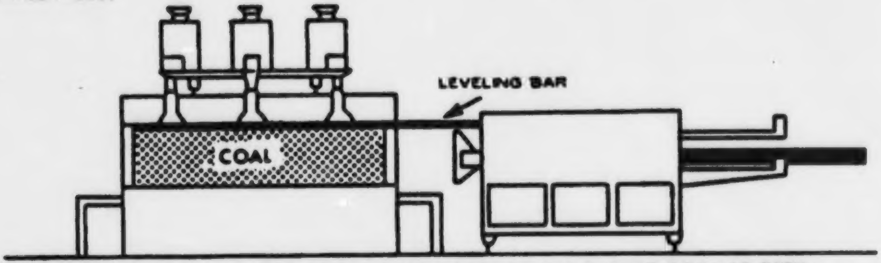
The loaded quench car is pushed into a semi-enclosed tower where water is sprayed on the hot coke to quench it. After the coke has been quenched, the quench car transports the quenched coke to the coke wharf where it is discharged. The coke is then screened to remove the fine particles (coke breeze) and transported by closed conveyor to the blast furnace.


SEPARATE CHARGING LARRY
EMPTY OVEN READY FOR CHARGING
PUSHER

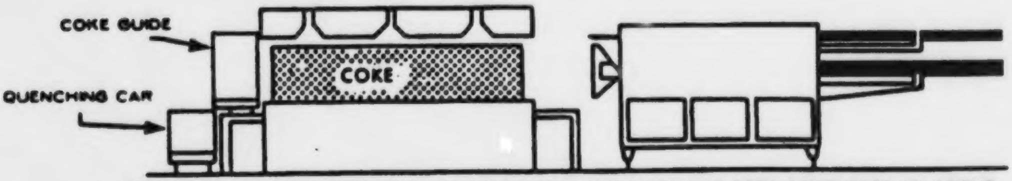
A THE CHARGING LARRY, WITH HOPPERS CONTAINING MEASURED AMOUNTS OF COAL, IS IN POSITION OVER CHARGING HOLES FROM WHICH COVERS HAVE BEEN REMOVED THE PUSHER HAS BEEN MOVED INTO POSITION.



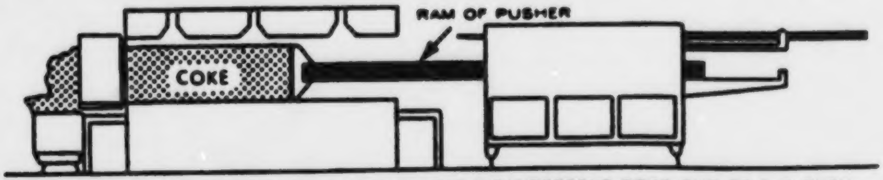
B. THE COAL FROM THE LARRY HOPPERS HAS DROPPED INTO THE OVEN CHAMBER, FORMING PEAKED PILES.


LEVELING BAR
COAL

C. THE LEVELING DOOR AT THE TOP OF THE OVEN DOOR ON THE PUSHER SIDE HAS BEEN OPENED AND THE LEVELING BAR ON THE PUSHER HAS BEEN MOVED BACK AND FORTH ACROSS THE PEAKED COAL PILES TO LEVEL THEM THE BAR NEXT IS WITHDRAWN FROM THE OVEN. THE LEVELING DOOR AND CHARGING HOLES ARE CLOSED, AND THE COKING OPERATION BEGINS


COKE GUIDE
QUENCHING CAR
COKE

D. COKING OF THE COAL ORIGINALLY CHARGED INTO THE OVEN HAS BEEN COMPLETED (IN ABOUT 17 HOURS) AND THE OVEN IS READY TO BE "PUSHED" THE OVEN DOORS ARE REMOVED FROM EACH END AND THE PUSHER, COKE GUIDE AND QUENCHING CAR ARE MOVED INTO POSITION


RAM OF PUSHER
COKE

E THE RAM OF THE PUSHER ADVANCES TO PUSH THE INCANDESCENT COKE OUT OF THE OVEN THROUGH THE COKE GUIDE AND INTO THE QUENCHING CAR

Figure 2.1.3.2 Sequence of Operations Involved in Charging, Leveling and Pushing in One Coking Cycle of a By-Product Coke Oven

A number of coke oven plants in Europe and Japan use dry coke quenching technology. The incandescent coke is pushed into an enclosed container and an inert gas is circulated through the coke to cool it. The heat absorbed by the inert gas (often nitrogen) is recovered and used to preheat coal (in those plants where preheating of the coal is also carried out) or to generate steam. Dry coke quenching becomes more economical in those areas where the relative cost of energy is high.

2.1.3.8 By-Product Plant

The gas exits the oven through a refractory-lined ascension pipe (standpipe) and into a gooseneck which connects into the collecting-main through a damper valve. The collecting main serves an entire battery of ovens, running parallel with the battery and extending above it on one side or both sides depending on whether it is a single or double main battery.

The gas and vapours leave the coke-oven at a temperature in the range of 600 to 700 °C, are shock-cooled by spraying with flushing liquor in the goosenecks and are then further cooled by spraying with flushing liquor at various points along the collecting main. Flushing liquor is the liquid resulting from the condensation of the water vapour leaving the coke oven and serves the dual purpose of cooling the gas and transporting the solids entrained in the coke oven gas and the liquids condensed out of the gas.

This flushing liquor is recirculated at a rate of 3 to 4.5 cubic metres per tonne of coal carbonized for single collector mains and up to 7.5 cubic metres per tonne for double collector mains.

The flushing liquor is collected in the flushing-liquor decanter tank where the tar and the solids that have exited from the coke-ovens settle out. The tar leaves the decanter tank through a decanter valve and is usually 2 to 5 percent water. When the tar contains an excess of water, it is allowed to remain longer in one of the intermediate tar tanks and the water that separates from the tar is returned to the flushing liquor. The tar is then used as a fuel or sold.

The solids which have been carried over from the coke ovens settle out from the flushing liquor in the decanter tank and are removed by a chain-driven scraper for disposal.

The flushing liquor volume is increased by the moisture from the coal in the coke ovens and a portion of the flushing liquor is discharged to the treatment plant with the balance being recycled.

The coke oven gas then passes through the direct primary cooler where the cooling liquor, which is cooled in an indirect heat exchanger, cools the gas and further condenses out tar and other compounds. These condensates are usually processed with the condensates from the decanter tank. The removal of the remaining tar in the gas stream is accomplished in an electrostatic precipitator.

About 25 percent of the ammonia formed during the coking process is contained in the flushing liquor (also known as weak ammonia liquor in the by-products plant) and the balance remains in the coke oven gas. Part of the ammonia in the flushing liquor is "free" (it readily dissociates by heat from compounds such as ammonium carbonate) while the balance is "fixed" (it does not readily dissociate with heat from compounds such as ammonium chloride or thiocyanate).

The ammonia in the flushing liquor is removed in a still where steam vaporizes the ammonia and acid gases. This is known as the "free leg" of the still. The flushing liquor then passes into the "fixed leg" of the still where calcium hydroxide reacts with the liquor and releases the "fixed" ammonia. In the past normal practice was to return the ammonia to the coke oven gas for use as a fuel. In recent years the ammonia is recovered in most plants. See Section 4.1.3 for the ammonia removal processes. Phenols formed in the coking process remain in the flushing liquor.

The coke oven gas then passes through the final cooler where the gas is cooled by direct water contact. Past practice was to remove the naphthalene from this water in a skimmer basin and discharge the wastewater. The modern practice is to use a side stream of wash oil to cool the gas and to cool the wash oil in an indirect water cooled heat exchanger.

The light oils are removed from the gas by direct scrubbing with wash oil. Wash oil is usually a petroleum wash oil that acts as a solvent and removes the light oils from the coke oven gas. The wash oil is then steam stripped in a still to remove the light oil, is indirect cooled, which causes the naphthalene to condense out, and is recycled. The main constituents of light oil are benzene (60-85%), toluene (6-17%), xylene (1-7%) and naphthalene (0.5-3%). When the wash oil is used as the final cooler cooling medium, the naphthalene content of the light oil increases.

The final gas processing step is the removal of hydrogen sulphide. See Section 4.1.4 for the hydrogen sulphide removal processes.

A typical yield of products of the by-product coke oven process is contained in Table 2.1.3.4.

TABLE 2.1.3.4 YIELDS AND ANALYSES OF PRODUCTS OF BY-PRODUCT COKE OVEN PROCESS

Product	Constituent	Percent of coal by weight
Coke		70.3
Gas	Carbon dioxide	1.04
	Carbon monoxide	3.15
	Methane	7.47
	Other hydrocarbons *	1.53
	Nitrogen	0.38
	Hydrogen	1.37
	Oxygen	0.72
	Totals	15.66
Ammonia		0.22
Tar		5.45
Flushing liquor	*	6.80
Light oils	*	1.10
Cyanogen		0.078
Carbon disulphide		0.013
Hydrogen sulphide		0.325

Note: * Sources of PAH

2.1.3.9 New or Emerging Technology

Better maintenance of existing coke oven batteries through the use of ceramic welding has improved operations, extended the life of existing coke ovens and, by making more extensive running repairs more feasible, has reduced coke oven leakage, thus having a positive impact on air pollution.

New door designs that are more flexible and follow more closely the changing contour of the door jambs reduce the incidence of door leaks. See Section 4.1.3 for a more detailed discussion of the new door designs and their impact on pollution control.

No replacement technology was identified for coke ovens. See Section 2.1.4 for discussion of new iron-making processes that may have an impact on coke ovens in the future. The injection of coal in the blast furnace, also discussed in Section 2.1.4, decreases the quantity of coke required by up to one third and, with further developments, possibly even more. The required coke oven capacity is also reduced, lessening the total pollution potential of the coke ovens.

2.1.4 Iron Production (Blast Furnace)

2.1.4.1 Blast Furnace

The blast furnace is a tall (usually over 35 metres) chimney-like structure with a steel shell and support structure lined with fireclay refractory brick. The blast furnace consists of four main parts: (1) the hearth - a cylindrical base, (2) the bosh - a short section above the hearth in the form of the frustum of an inverted cone, (3) the stack - a long shaft above the bosh tapering upwards, and (4) a top closed by a system of double conical gates known as bells.

The blast furnace reduces the impurities in iron ore producing pig iron, ** a material that contains over 90% iron. The iron ores used to produce iron are largely composed of iron oxides. Obtaining metallic iron, therefore, is primarily a matter of removing oxygen from the iron ore and, to a lesser degree, removing some of the impurities (such as silica) contained in the iron ore. This is accomplished through the use of heat and carbon, mainly in the form of coke. In the blast furnace, reduction (in the sense of de-oxidizing) takes place in two stages. The process begins with indirect reduction - oxygen combines with incandescent coke to form carbon monoxide, converting part of the iron ore to iron and part to iron monoxide. Afterwards, in direct reduction, the hot carbon converts all the ore into metallic iron. Most of the pig iron produced in steel plant blast furnaces is transported in a molten state to the steel-making furnaces.

** So called because of an early arrangement of running the molten iron into small sand moulds arranged around a main channel like a litter of small pigs around their mother. The main channel was called a sow.

The typical blast furnace plant contains a number of auxiliary structures.

In modern blast furnaces an inclined belt conveyor transports the charge materials from ground level to the top of the blast furnace for charging into the blast furnace. Many older blast furnaces use skip hoists and cars instead of belt conveyors.

Three and sometimes four stoves are used to pre-heat the blast air for the blast furnace. The stoves are a type of recuperator that stores the heat generated by the combustion of fuel gases including blast furnace gas, coke oven gas and natural gas. The stoves contain refractory checker brick that is heated by the fuel combustion and then the blast air is directed through the hot stove while another stove is being heated.

The blast furnace gas generated in the iron-making process exits the top of the blast furnace and coarse dust is removed in the dust catcher, a large cylindrical structure. The gas then goes to the blast furnace gas cleaning system. A typical blast furnace gas composition and its properties are contained in Table 2.1.4.1.

2.1.4.2 Charge Materials

The charge materials are: (1) major iron-bearing materials, (2) minor iron-bearing materials, (3) fluxes and (4) coke. The combination of the first three is known as the burden.

Major Iron-bearing Materials:

The major iron-bearing materials are iron ore, sinter and pellets. Iron ore that is charged into the blast furnace usually contains about 50 to 65 percent iron and impurities such as silica and alumina. Some of the pellets and sinter contain flux materials.

TABLE 2.1.4.1 TYPICAL BLAST FURNACE GAS COMPOSITION AND PROPERTIES

Gas Composition	Percent by Volume (1)
CO_2	11.5
N_2	60.0
CO	27.5
H_2	1.0
Total	100.0
Property	
M^3 of air required for combustion	0.68
Specific gravity	1.02
Heating value per unit volume of gas:	
Gross	3,614 kJ/m^3
Net	3,614 kJ/m^3
Theoretical flame temperature (no excess air)	1454 °C

NOTE: (1) All volumes at 0 °C and 101.325 kPa

Source: The Making, Shaping and Treating of Steel, 10th Edition, Association of Iron and Steel Engineers

Minor Iron-bearing Materials:

The minor iron-bearing materials are mill scale, steel-making slag and scrap.

Mill scale consists of iron oxides that have formed on the surface of steel during heating prior to rolling and is removed from the steel before entering the rolling mill. It is usually a source of relatively pure iron oxide.

The steel-making furnace slag is the fused iron impurities and steel-making fluxes that have been separated from the molten iron during the steel-making process. These slags usually contain up to 25 percent iron with a basic composition due to the un-reacted fluxing agents remaining in the slag.

Iron is also obtained from scrap recovered from steel-making slag, iron scrap produced at the blast furnace and small scrap not suitable for steel making.

Fluxes:

Many of the impurities in the iron ore have a higher melting point than that of iron. Fluxes are added to the charge to combine with these impurities which then melt at lower temperatures and form a fluid slag that floats to the top of the molten iron. The major flux materials are limestone, burnt lime and dolomite. The flux charge and composition are carefully controlled to preserve the sulphur-holding power and fluidity of the slag. The slag consists of lime-alumina-silicates and heavy metal oxides.

Fuel:

Coke, a solid fuel obtained by the destruction of bituminous coal, is charged to the blast furnace to: (1) provide the heat required to melt the iron and its impurities; (2) provide the chemical reagents, carbon and carbon monoxide, for reducing the iron ore; (3) supply the carbon that dissolves the hot metal (molten iron) and reacts with the molten iron to form an iron-carbon alloy; and (4) act as a structural material that helps support the burden and maintain gas passages through the burden.

2.1.4.3 Furnace Operation

Charging the Furnace

The raw materials are raised to the top of the blast furnace by conveyor belt and are dumped into a receiving hopper which feeds a rotating distributor to provide uniform distribution of materials in the furnace stack. Two or three conical bells situated below the distributor provide a seal to prevent gas from escaping while the furnace is being charged. The material is charged onto the open top bell (small bell) with the bottom bell (large bell) closed, the top bell is closed and the bottom bell is lowered allowing the material to fall into the furnace.

One of the important functions of the blast furnace charging system is the proper distribution of the charged material to assure good contact between the rising gas and the charge materials. Formerly, fines would separate from the coarse materials and accumulate near the bells so that the gas would flow through the coarser material without making adequate contact with the fine materials.

Several approaches have been developed to overcome this problem. One is the McKee distributor, a rotating small-bell hopper that varies the location in which the particles accumulate. A second consists in varying the sequence of charge materials on the large bell. A third, used especially for large new furnaces, employs moveable stockline armour that can be shifted in and out to change the position of the material as it slides off the bell. A fourth, also for larger furnaces, is a rotating chute that, by means of variable angle and speed settings, places each charge where it will give the best distribution, eliminating the big bell entirely.

Heating the Furnace

The blast furnace stoves are heated with gaseous fuel, usually blast furnace gas enriched with coke oven gas. The blast air, which is usually generated by steam-driven centrifugal turbo-blowers, is heated while passing through the hot stoves. The hot blast air is conducted from the stoves to the furnace to the bustle pipe. circling the furnace. The air enters the blast furnace through water-cooled openings or tuyeres located at the top of the hearth and causes part of the coke to burn and form carbon monoxide. The heat of combustion raises the temperature of the coke to incandescence, drives the carbon dioxide out of the fluxes, dries the ore in the stack and reduces the iron ore by the combining of the carbon monoxide with the oxygen in the iron ore.

Melting the Iron

As the iron ore, coke and flux slowly descend the stack, the non-ferrous materials mix intimately with the reduced iron. Separation of the materials does not take place until near the top of the bosh where both the iron and the slag (non-ferrous materials) begin to melt. As melting proceeds, volume lessens making room for new raw materials to be added at the top. From the bosh the melted iron, freed from impurities, trickles down to the furnace hearth. On the hearth bottom, molten pig iron collects in a pool covered by a layer of molten slag.

Tapping the Furnace

At regular intervals the iron and slag that accumulate in the hearth are removed in an operation called tapping. Every blast furnace is equipped with at least two holes for tapping: (1) the iron notch, located slightly above the floor of the furnace, through which the iron is drawn and (2) the cinder notch (or slag notch), located one to two metres above the iron notch, for removing the slag.

Most modern furnaces are built with two or more iron notches, which, with modern charge preparation techniques that produce fewer impurities, are now used to tap slag as well as iron.

When the furnace is in operation, the iron notch is filled with refractory material, through which a tapping hole is drilled. After the cast is completed, the hole is again filled with refractory material.

As the hot metal leaves the tapping hole, it is discharged into the trough, a refractory basin one to two metres wide and eight to twelve metres long. At the end of the trough, remote from the furnace, is a dam to hold back the molten metal until it is deep enough to touch the bottom of a refractory skimmer block which diverts the slag into the iron runner. The molten iron is separated from the slag by means of a dam and skimmer and is then directed to the train of ladles positioned under stationary spouts along the runner.

2.1.4.4 Auxiliary Operations

Hot Metal Transportation

The hot metal is transported from the blast furnace to the steel-making shop in insulated, refractory-lined ladles.

The most common type of ladle is shaped like a submarine and is on rail trucks with an opening at the top to receive and discharge the hot metal. The ladle is rotated to discharge the metal.

In most modern plants the hot metal is de-sulphurized in the ladle at a ladle de-sulphurization station where reagents such as calcium carbide, lime-magnesium or lime-aluminum are injected either prior to transport to or on arrival at the steel-making shop. The typical sulphur reduction is from 0.04 - 0.06 percent S to 0.015 - 0.020 percent S.

If the phosphorus content of the iron is too high, another reagent is added to remove some of the phosphorus. Phosphorus removal is less prevalent in North America than in Japan because of the lower phosphorus content in the raw materials.

Some of the carbon comes out of solution as the molten pig iron cools during the transportation to the melt shop. This carbon (also known as kish) and the balance of the slag in the iron ladle are usually dumped from the ladle in a de-kishing station into water to granulate the slag. The slag and kish material are reclaimed from the water for recycling.

Some plants cast a small portion of the hot metal into pigs at a pig machine either for sale or for stockpiling for future use.

Slag Disposal

The molten slag is handled in several ways depending on the end use of the slag, the available space at the blast furnace and the plant practice. A common way has been to run the slag into a pit where, after a cooling period, it is quenched with water sprays. After cooling, the slag pit is excavated and the slag is usually sold as a raw aggregate material for construction.

Increasing use is being made of processes that granulate or pelletize the molten slag. A typical process is to quench the slag rapidly in water or to pour the stream of molten slag onto a rotating water wheel which solidifies the slag into spherical pellets. The cellular structure of the quenched (expanded) slag is more pronounced than that of the air-cooled slag. The expanded slag is used as a construction aggregate (eg. for light-weight concrete products). Some slag is also used in a dispersion-to-fibre process to make rock wool.

2.1.4.5 New or Emerging Technology

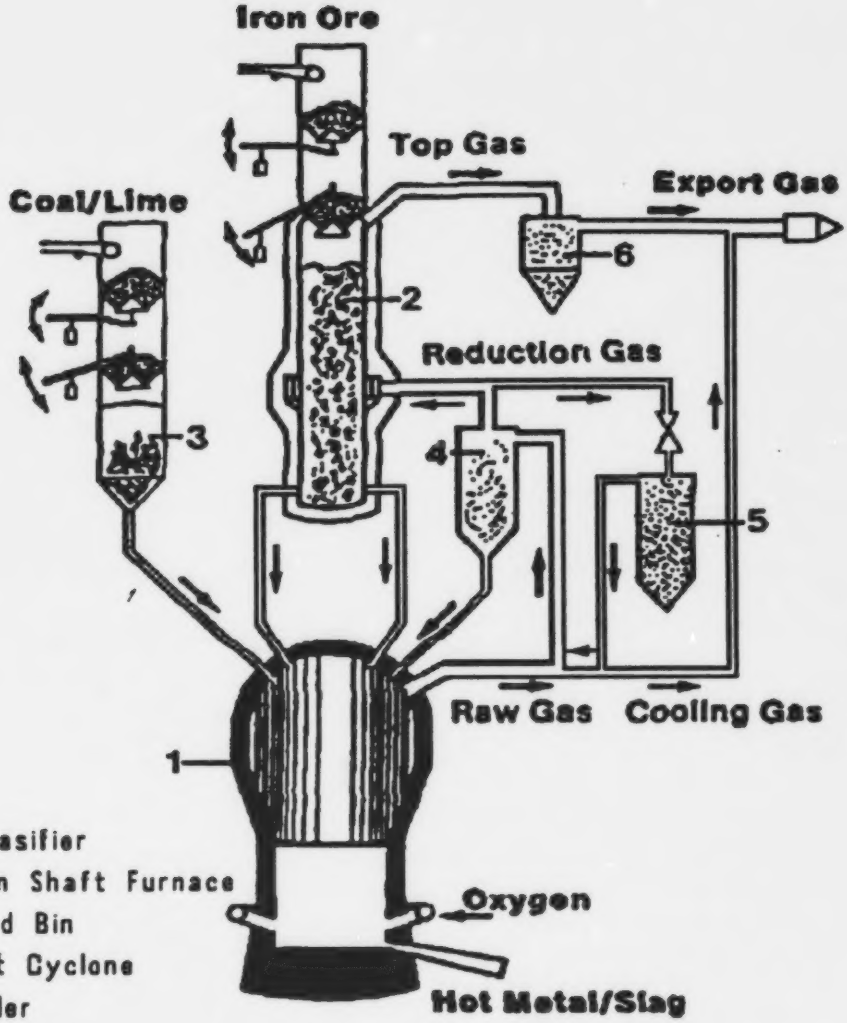
Metal Reduction Technologies

Considerable research has been undertaken - in fact, is still ongoing - in the development of direct iron-making technologies. The major incentives for such technologies include:

1. Direct use of coal which eliminates the coke plant.
2. High production rates (tonnes/m^3 day).
3. Direct use of ore with no pellet or sinter plant required.
4. Lower capital cost and possible lower operating cost.
5. Economical on a small scale.

The most advanced in terms of development is the COREX process. A schematic of this process is shown in Figure 2.1.4.5.1. A plant with a capacity of 300,000 tonnes per year has been started up in South Africa. The process consists of a reduction shaft furnace combined with a melter gasifier vessel. Iron ore is reduced (90 percent) in the reduction shaft furnace (The reduction gas is generated in the gasifier melter.) and charged into the melter gasifier. Coal is injected into the melter gasifier to complete the iron reduction and generates reduction gas, part of which is used in the reduction shaft furnace. The balance is exported for plant use. Lime is injected into the melter gasifier as a flux and oxygen is injected for the smelting process.

The COREX process appears promising, but there are questions as to the extent to which it can be scaled-up. The process has several drawbacks in that it produces much more gas than is required in most steel plants (As much as 50% of the energy would be surplus to the steel plant.), not all types of coal can be used and some ore agglomeration is required. This process is 5 to 10 years away from replacing the blast furnace in a large greenfield plant.


Iron Ore
Top Gas
Export Gas
Coal/Lime
6
2
Reduction Gas
3
4
5
Raw Gas
Cooling Gas
1
Oxygen
Hot Metal/Slag

Legend

1 Melter Gasifier
2 Reduction Shaft Furnace
3 Coal Feed Bin
4 Hot Dust Cyclone
5 Gas Cooler
6 Top Gas Cooler

Figure 2.1.4.5.1 The COREX Ironmaking Process

Bath Smelting Processes

In these processes, coal, oxygen and partially pre-reduced iron ore are reacted in an iron bath. Post combustion of the off gases (CO and H_2) supply much of the required energy. A schematic diagram of bath smelting is shown in Figure 2.1.4.5.2. The post-combusted gases are then used to do a small amount of pre-reduction (for example, to FeO only). Processes are being developed by CRA-Klockner (Hismelt), Nippon Steel, NKK Corporation and AISI-DOE. The key to these processes is a high degree of post combustion with effective heat transfer. Work to date has shown that the approach is technically feasible. However, there must be a scale-up from bench-scale or pilot-plant size to high production rates in larger vessels before the processes can be considered for commercial use. Although some of these processes (eg. NKK) are approaching the pilot-plant stage, it is unlikely that will be suitable for a large greenfield steel plant before the end of the decade.

Blast Furnace Improvement Technologies

There are a number of advances being made in blast furnace technology. These include the following:

1. **Beneficiated Charge Materials** - The quality of the blast furnace raw materials is increasingly leading to greater beneficiation of the iron-bearing materials and especially the greater use of pellets. This trend, together with the increased addition of fluxes to the pellets (or sinter), has increased blast furnace production due to the reduction in slag volume and improved furnace operation.

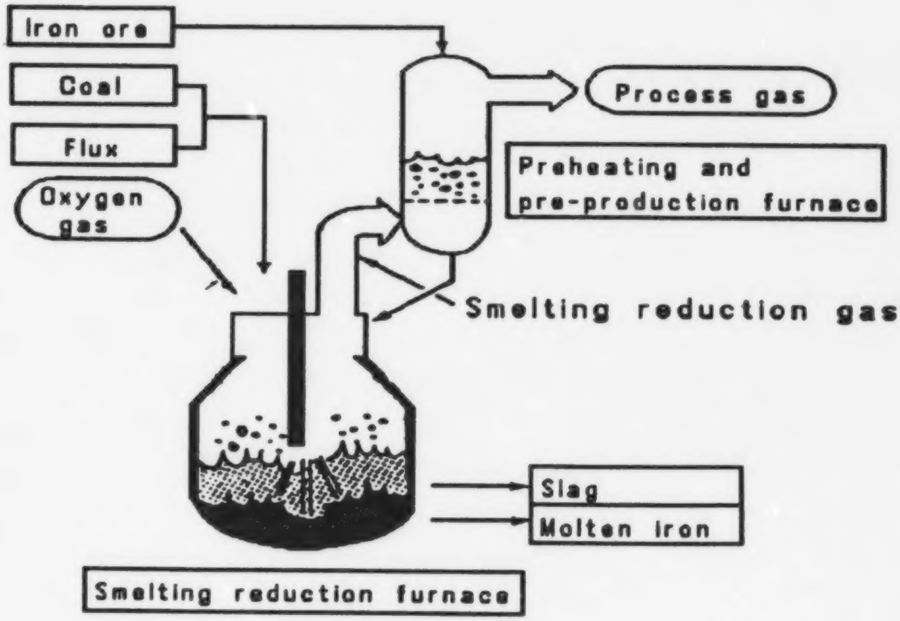

Iron ore
Coal
Flux
Oxygen gas
Process gas
Preheating and pre-production furnace
Smelting reduction gas
Slag
Molten iron
Smelting reduction furnace

Figure 2.1.4.5.2 Schematic diagram of bath smelting

2. **High Hot-Blast Temperatures** - Developments in improved stove-firing techniques, improved stove-changing equipment, the use of higher-quality raw materials (beneficiated charge materials), the greater use of tuyere-injected fuels and the improved control of blast moisture have resulted in increased fuel efficiency. These developments have led to the use of higher hot-blast temperatures, which in turn has resulted in improved furnace operation, higher furnace production and increased productivity. Hot-blast temperatures of 1200 to 1250 °C are now common and temperatures as high as 1272 °C are being achieved.

3. **Fuel Injection** - While fuel injection of oil and gas have been practised in North America on several blast furnaces, the use of coal for injection in the tuyeres has not been as advanced in North America as in Europe and Asia. New coal injection technologies now allow the injection of up to 150 kg of coal per tonne of hot metal on a routine basis and up to 250 kg per tonne on a developmental basis.

   Since the injection of one kg of coal has been proven to be roughly equivalent to one kg of coke, the injection of 150 kg of coal per tonne would reduce the coke rate from 450 - 460 kg per tonne to about 300 kg per tonne or a reduction of one third. This results in the requirement of a much smaller coke oven installation for a given hot metal output. Since the cost of the coal, including the annualized cost of the coal injection system, is considerably lower than the cost of coke, there would be a reduction in operating costs of the furnace. Most grades of coal can be used and even lignite has been used on a trial basis in Germany.

The coal is ground to approximately 95 percent <2mm (granular coal) for some installations and even finer (pulverized coal) for other installations. The choice between pulverized and granular coal depends on the plant operating practice and the coal injection system vendor that is selected.

4. **Oxygen Enrichment of the Blast** - New techniques and methods for controlling the flame temperature, together with blast moisture control and fuel injection, have led to increased enrichment of the blast air. It has been proven that each percent increase in oxygen in the blast air can increase the production rate by 2 to 4 percent and significantly increase fuel efficiency.

5. **High Pressure Operation** - Increasing the volume of air blown into the blast furnace can increase the rate of production provided that the furnace is designed for the higher blowing rate. The major change is an increase in the top pressure in the furnace with typical top pressures as high as 200 kPa. The high top gas pressure is controlled by septum valves that increase and control the exit-gas pressure. With the higher top-gas pressures it also becomes more economical to add energy recovery from the top gases through the addition of a gas turbine energy recovery system.

Projected New Iron-Making Process Technology Applications:

It is likely that the blast furnace will continue to be the predominant hot metal process for steel making in the short-term. No process appears to be in a position to challenge this role for the next five years or so. After about five years an iron-making process, such as COREX, may be suitable for use in incremental expansions of iron-making capacity in some integrated steel plants.

However, it is unlikely that such a process will challenge the blast furnace for a greenfield plant for at least a decade since no process has yet been satisfactorily operated for a significant period of time as a production unit. Once such a process has been operated as a demonstration plant, it will take time, possibly a decade, to achieve the scaled-up size and demonstrated reliability required for a new greenfield integrated steel plant.

In the interim, progress will continue to be made in reducing the blast furnace dependence on coke-making and in reducing the environmental impact of the conventional hot metal production processes. It appears that the most important developments will be made in the replacement of coke in the blast furnace by coal, improved blast furnace operation, increased recycle of iron-bearing waste materials generated in the steel plant and increased steel yields to reduce the amount of hot metal required.

2.2 Steel Making

2.2.1 Material Handling

The major raw materials for steel making are the molten iron from the blast furnace and steel scrap, either revert (in-plant scrap) or purchased. The molten iron is usually transferred by rail using torpedo-type ladle cars, although other types of ladle cars are used in a few plants. The ladle car is moved into a building adjacent to the steel-making furnace bay and the ladle portion of the car is rotated causing the molten iron to pour into a melt shop ladle. The majority of the slag in the ladle car remains in the ladle car and is then removed in the de-kishing station referred to in Section 2.1.4 or dumped into a slag pot or dump. The ladle, containing the molten iron, is then transferred into the furnace bay for charging.

Purchased scrap is transported into the plant by truck or rail car and is unloaded in the scrap yard adjacent to the steel melt shop. The scrap is sorted and stored by grade and type. The revert scrap is also transported to the scrap yard for storage prior to use. Revert scrap is preferred since the grade is known and the quality is usually higher than purchased scrap which often contains non-steel materials or mixed grades of steel. The scrap is loaded into scrap-charging buckets and transferred to the furnace bay for charging.

Fluxes are an important but lower-volume material used to remove impurities from the molten iron in the melting and refining process. The most important fluxes are burnt lime (produced by calcining high calcium limestone), burnt dolomite and fluorspar. From 50 to 100 kg of burnt lime and 15 to 18 kg of burnt dolomite are used per tonne of steel produced. The fluxes are transported to the melt shop by either truck or rail car and are elevated to the storage bins in the melt shop by conveyor or by pneumatic conveying.

Oxygen is an essential raw material for steel making in the basic oxygen furnace and to a much lesser extent in the electric furnace. About 75 kg of oxygen is used per tonne of steel produced in the basic oxygen furnace. High purity oxygen is required in the basic oxygen furnace to minimize detrimental effects of the impurities, such as nitrogen, on the steel. This tonnage oxygen is produced in cryogenic plants. Oxygen-producing plants may be located adjacent to the melt shop or some distance from the plant. The oxygen is transported to the melt shop by pipeline.

2.2.2 Basic Oxygen Steel Making

2.2.2.1 Oxygen Steel-Making Process

Oxygen steel-making processes are concerned mainly with the refining of a metallic charge consisting of hot metal (molten pig iron) and scrap through the use of high-purity oxygen to rapidly produce steel of the desired carbon content and temperature. Various steel-making fluxes are added during the refining process to reduce the sulphur and phosphorus contents of the bath to the desired level. The oxygen processes typically produce a 150 to 250 tonne heat of steel every 45 to 60 minutes with only about 15 minutes of this total time being used for the final refining. Charging of the furnace, sampling and testing for the steel composition, measuring the steel temperature, tapping the steel and pouring off the slag generally account for the balance of the time.

Each steel-making process has been designed primarily to provide a means whereby controlled amounts of oxygen can be supplied to the molten metal undergoing refining. The oxygen combines with the unwanted elements (with the exception of sulphur) and unavoidably with some of the iron to form oxides which either leave the bath as gases or enter the slag.

Modern oxygen steel making has evolved into three basic processes depending on the method by which the oxygen is introduced into the bath: (1) top-blown converter, (2) bottom-blown converter and (3) combination blowing.

In all three processes the converter is a pear-shaped steel vessel lined with refractory material and with an open top and is supported on two sides by trunnions allowing the converter to tilt forward and backward. The converter is tilted forward when the scrap and hot metal are charged into its open mouth and backwards when the steel or slag is poured out.

In the top-blown converter (BOP or BOF), the oxygen is introduced into the bath through a vertical pipe (lance) with special nozzles in the bottom to impart a supersonic velocity to the exiting oxygen jets. The lance is water cooled and is lowered into the vessel through the mouth opening.

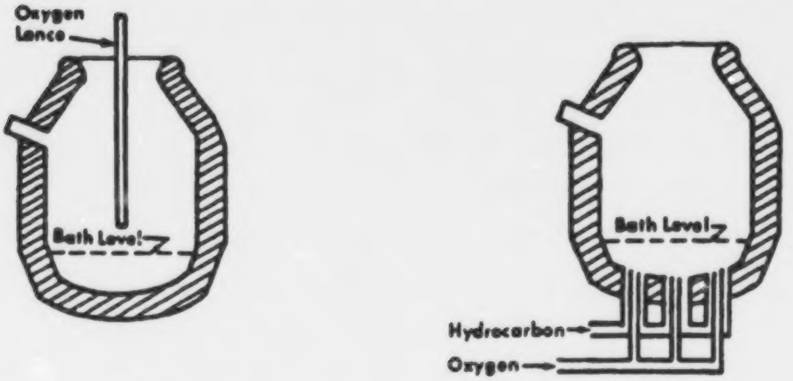
In the bottom-blown process (Q-BOP), oxygen is introduced through a number of tuyeres in the bottom of the converter. The oxygen is blown through the inner pipe of two concentric pipes while hydrocarbon gas coolant is injected through the annulus between the two pipes.

One variation of the BOP is a top-blown system with bottom stirring. Oxygen is introduced through a top lance, similar to top-blown converters, and an inert gas is blown through tuyeres or permeable elements in the bottom to stir the bath.

In the combination blowing process part of the oxygen is introduced through the top lance and the balance through the bottom tuyeres. Natural gas is usually injected through the tuyeres as a tuyere coolant and part of the lime flux is also injected through the tuyeres.

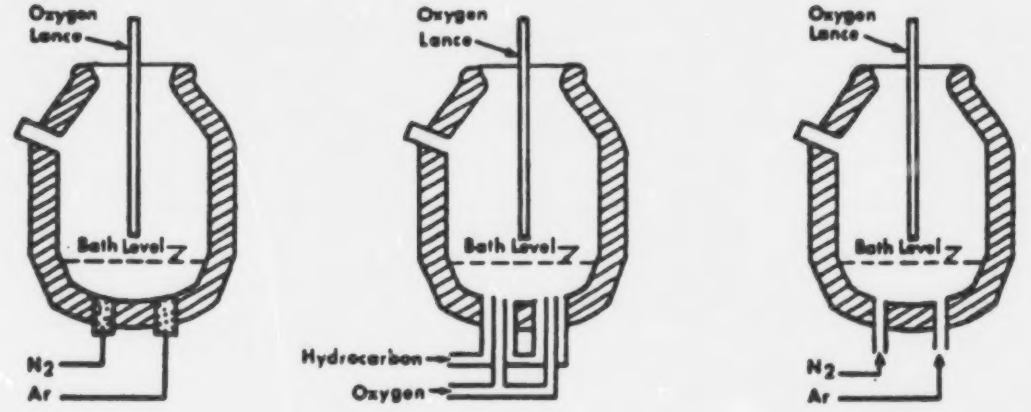
Figure 2.2.2.1 is a sketch representation of these three different types of oxygen steel-making converters.

In the 1960's and the early 1970's, the top-blown converter process was the leading oxygen steel-making process. By 1978, the bottom-blown oxygen steel-making process had emerged as a new technology with specific metallurgical advantages. The primary advantage of the bottom-blown converter process is that it operates much closer to equilibrium conditions between the metal and the slag and is, therefore, much lower in oxidation potential.


Oxygen Lance
Bath Level
Bath Level
Hydrocarbon
Oxygen

Top-Blown (BOP) Process

Bottom-Blown (Q-BOP) Process


Oxygen Lance
Bath Level
N_2
Ar
Oxygen Lance
Bath Level
Hydrocarbon
Oxygen
Oxygen Lance
Bath Level
N_2
Ar

Top lance plus permeable elements in bottom

Top lance plus cooled bottom tuyeres

Top lance plus uncooled bottom tuyeres

Combination-Blown Processes

Figure 2.2.2.1 Representation of basic oxygen process converters for steel making.

The use of bottom blowing leads to lower iron losses to the slag, higher manganese recoveries, less slopping, faster blow times, improved phosphorus and sulphur control and lower dissolved oxygen and nitrogen contents. The result is an increase in yield of 1.5 to 2 percent and easier process control. The main disadvantage is the reduction in scrap usage.

By 1982 the combination-blown processes had emerged to approach the metallurgical advantages of bottom blowing without abandoning the higher scrap usage of the top-blown converter.

The oxygen steel-making process is similar for all three types of converters. Steel scrap, including that scrap produced within the steel mill, is charged into the hot vessel. Scrap metal is usually less expensive than hot metal, so one objective is to increase the proportion of scrap used in the converter. Typically 20 to 35 percent of the metal charge is scrap with the bottom-blown converters having a lower scrap usage than top-blown converters. In some cases, the scrap is pre-heated in the converter in order to use a higher proportion of scrap. The scrap is usually charged by special scrap buckets handled by the overhead crane. The bucket is tilted to slide the scrap out of the bucket into the mouth of the furnace.

Hot metal is poured from the blast furnace hot metal car into a ladle in the melt shop. The ladle is then lifted by the overhead crane, and the hot metal is poured into the open mouth of the converter. The converter is returned to the upright position and oxygen blowing is begun. The reaction with the impurities in the bath commences almost immediately, and the prescribed weight of fluxes is added to the converter through a flux chute in the hood above the furnace. When the blow is completed, the converter is tilted forward, a temperature reading of the molten steel is taken and a sample of the molten steel is obtained and sent to the nearby chemical laboratory where it is analyzed for specific elements.

If the steel is too hot, the furnace is returned to the upright position and a coolant, iron ore or limestone, is added to the bath. If the temperature is too low, the oxygen blowing is resumed for a short time. The requirement for re-blowing and its duration are also dependent on meeting the chemistry requirements for elements including carbon, sulphur, manganese and phosphorus.

The furnace is then tilted in the other direction and the molten steel is poured into a ladle for further processing. The slag is poured into a slag pot for cooling and disposal.

2.2.2.2 Oxygen Steel-Making Technology Developments

The major new developments in oxygen steel-making technology are in the areas of improved process control, increased scrap utilization and improvements to the combination-blowing process. The further development of Static Charge Control will lead to a number of expected benefits including:

1. improved control of carbon, phosphorus, sulphur contents and temperature at tap
2. decreased time to make a tap
3. improved heat-size control
4. decreased use of hot-metal, coolants and oxygen
5. decreased use of fluxes
6. improved yield
7. improved steel quality.

Good control of high-purity oxygen steel-making processes requires more than the availability of an on-site process control computer with a charge-control model. To obtain good charge control, improvements in the accuracy and reliability of the measurements of all computer inputs must be made.

On-going development work on the combination-blowing process is aimed at increasing the scrap charge, improving steel quality and reducing operational and material costs. Developments in preheating scrap in the combination-blown converter have increased the scrap charge by over 2.5 percent. Further improvement is anticipated. A combination-blown converter process involving a dual converter installation is being developed for a 100 percent scrap process.

The development of limited post-combustion of off-gases before they enter the hood is expected to improve the thermal efficiency of the converter. The injection of recovered iron oxide containing dusts would further improve yield while eliminating one of the steel plant waste materials.

Projected New Steel-Making Process Technology Applications:

No replacement for the basic oxygen process for steel making appears to be on the horizon. However, it is likely that within a decade a continuous steel-making process, based on the AISI research and development or on similar research and development approaches in Japan and elsewhere, will be at the demonstration stage. In fact, there may be a suitable replacement process for an integrated greenfield steel plant in the next decade. Whatever process is adopted, it will likely replace the blast furnace as a source of hot metal.

In the interim the basic oxygen process will be further refined with the objectives of increasing quality and yields and reducing costs and environmental impact.

2.2.3 Electric Furnace Steel Making

2.2.3.1 Electric Furnace Steel-Making Process

The electric furnace steel-making process is generally used for the production of alloy and speciality steels (such as tool steel or stainless steel) and low to medium tonnages of carbon steel. The major use of the electric furnace steel-making process in producing tonnage carbon steels is in areas where there are high scrap availability and low-cost electric power. Part of the scrap requirement can be met by the use of direct-reduced iron. Electric arc furnaces are not normally used for production of over 1.5 million tonnes per year at a single location. This process is most suited to the production of steel in areas where the market is too small to justify using the combination of a blast furnace and a basic oxygen furnace to produce steel.

Scrap sorting, segregation and quality are very important for the production of steel in an electric furnace since it is necessary to retain the alloys contained in the scrap. Because there is usually no virgin metal (molten pig iron) added to the charge, it is more difficult to remove impurities that may be contained in the scrap. When the steel is melted and refined in an electric arc furnace, the yield is usually 90 percent or better. The loss consists primarily of: (1) metal lost in the slag as iron oxide and metallic steel droplets, (2) iron vaporized from the bath and collected in the gas cleaning system and (3) steel lost during casting and teeming.

The electric furnace has a removable roof which swings to one side for scrap charging. The scrap is usually charged using a drop bottom bucket and the overhead crane. Large pieces of scrap, such as large ingot butts or broken rolls, are usually lowered into the furnace by magnet to avoid damage to the bottom of the furnace. Once the furnace is charged, the power is turned on and the electrodes are lowered to start melting the scrap.

The melt-down period is the most expensive period of the operation because of the high power and electrode consumption needed to reduce the melt-down to as short a period as possible.

Once the bath is molten, impurities such as phosphorus, silicon, manganese and carbon are oxidized by the injection of oxygen through a lance into the bath. Oxygen consumption in many operations now exceeds 30 Nm^3 per tonne of steel produced. Most carbon steel and low-alloy steel grades made in electric arc furnaces are made by a single slag process. As soon as the charge is melted, a steel sample is taken and analyzed in the chemical laboratory to determine the steel composition adjustments that are required. Once the steel composition and temperature are satisfactory, the steel is tapped out of the furnace.

When a heat is tapped, the electrodes are raised high enough to clear the bath in a tilted position, the tap-hole is opened and the furnace is tilted so that the steel is drained out of the furnace into a ladle. The slag may be tapped before, with or after the steel depending on the operating practice of the plant. The ladle of molten steel is transferred to the ladle refining unit, teeming floor or continuous casting machine for further processing.

2.2.3.2 Electric Steel-Making Technology Developments

The increased computerization of electric arc furnace melt shops will continue with developments being made in the field of computer programs and measuring devices. The objective is to improve furnace operations and steel quality while reducing the consumption of materials and electric power and increasing work force productivity.

An example is the development of Direct-Current Electric Arc Furnaces. The progress in power thyristor technology gave impetus to the recent developments in D.C. Electric Arc Furnaces. The advantages of these systems include lower electrode consumption, smaller electrical utility system requirements, lower noise level and a more homogeneous bath.

Other areas of productivity improvement and increased production efficiency include higher oxygen lancing rates, carbon addition to the bath and the use of foaming slag.

While steel production based on the electric arc furnace process will continue to grow, it does not appear that this process will successfully challenge the blast furnace-oxygen steel-making combination for large integrated steel plants. It is likely that the electric arc furnace will continue to be used for small- to medium-size steel plants. Assuming that near-net-shape continuous casting technology will be demonstrated for flat products, the electric arc furnace will make further inroads into the integrated steel plant product areas. The limiting factor is likely to be the availability and cost of electric power for electric arc furnace steel production.

2.2.4 Vacuum Degassing and Ladle Metallurgy

2.2.4.1 Ladle Metallurgy Processes

The purpose of Secondary Steel Making (also referred to as Ladle Metallurgy) is to produce "clean" steel, steel which satisfies stringent requirements of surface, internal and micro-cleanliness quality and of mechanical properties. Ladle metallurgy is a secondary step of the steel-making process often performed in a ladle after the initial refining process in a primary furnace is completed. Increasingly stringent requirements have been demanded of a growing percentage of steels and only the process of ladle metallurgy can economically satisfy these requirements.

Ladle metallurgy processes are adopted primarily to meet objectives which result in a steel that meets the desired stringent requirements. These objectives include:

1. Control of entrained gases: degassing (decreasing the concentration of oxygen and hydrogen in steel)
2. Low sulphur contents (normally less than 0.010 percent and to as low as 0.002 percent)
3. Micro-cleanliness (removal of undesirable non-metallics, primarily oxides and sulphides)
4. Inclusion morphology (Since steel makers cannot remove undesirable oxides completely, this step allows them to change the composition and/or shape of the undesired matter left in the steel to make it compatible with the mechanical properties of the finished steel.)
5. Mechanical properties.

Although ladle metallurgy processes can extend the refining capabilities of modern steel-making facilities, various prerequisites must be met for effective use of these processes.

These include:

1. Temperature and chemical composition of the raw steel must meet certain requirements.
2. The carry-over of steel-making slag into the steel ladle must be minimized. In the production of ultra-clean steels, the slag may be raked off the ladle and be replaced by a synthetic slag (ie. lime-silica-alumina mixture).
4. Accurate assessment of the temperature, chemical composition and quantity of steel in the ladle is necessary.
5. The use of higher-quality refractory materials is required in the liquid steel handling facilities.
6. Ladle pre-heating and slide gate-equipped ladles become more important.

There are three broad classifications of ladle metallurgy processes: (1) vacuum degassing, (2) vacuum degassing and refining with the capability for supplemental reheating of steel and (3) non-vacuum ladle or vessel refining without reheating.

Vacuum degassing processes refer to the exposure of the molten steel to a low-pressure environment to remove gases from the steel. This may be done by one of the following methods:

1. Stream degassing:

    a) ladle-to-mould degassing - The molten steel stream flowing from the ladle to the mould is subjected to a low-pressure environment.
    b) ladle-to-ladle degassing - The steel is poured from one ladle to a second ladle and the molten stream of steel is subjected to a low-pressure environment.

c) tap degassing - The furnace is tapped into a tundish on the top of an enclosed ladle and the ladle is evacuated with the molten stream of steel flowing through a low-pressure environment.

2. Vacuum degassing and refining with the capability for supplemental reheating of steel:

   a) recirculation degassing - The liquid metal in a ladle is forced by atmospheric pressure into an evacuated degassing chamber where it is exposed to low pressure and then flows back into the ladle.
   b) vacuum ladle degassing - The ladle is placed in a vacuum vessel and the vessel is evacuated. The vessel may be equipped with induction coils which stir the molten steel by inducing eddy currents in the steel or the steel may be stirred by injecting argon through a lance.
   c) vacuum degassing - An external source of heat (electrical arc or induction coils) is used along with the vacuum degassing.

3. Non-vacuum ladle or vessel refining without reheating:

   a) argon bubbling - Argon is injected into the molten steel through a lance.
   b) argon-oxygen decarburizing (AOD) - An argon-oxygen mixture is injected into the molten steel through a lance (usually used for stainless steel only).
   c) electroslag remelting - A steel electrode is drip-melted through molten slag into a water-cooled copper mould (usually used for speciality steels only).

d) ladle injection - Deoxidizers, special materials and rare earth metals are added to ladles of steel.

In the majority of ladle metallurgy applications, fluxes and alloying materials are added to achieve the desired steel composition.

2.2.4.2 New Developments in Ladle Metallurgy

New process technology is being developed in the following areas:

- Slag separation technology - involves process engineering improvements to assure complete retention of slag in the steel-making furnace and improved methods of slag removal from the ladle.

- Phosphorus removal - new methods of injecting fluxes, removal of slags and metal stirring.

- De-sulphurization - to achieve lower sulphur levels in the steel.

- Carbon control - to achieve lower carbon in some steels, possibly to the 20-30 ppm carbon range.

- Nitrogen - improved nitrogen control and removal.

- Oxides and alloying - improved methods of adding fluxes and alloys development of filtration processes to remove slag.

- Analyses and sensors - development of new, reliable, accurate sensors for instantaneous analyses of key elements.

- Heating - improved heating or re-heating methods to obtain faster temperature recovery with the least disruption of the analysis of the liquid.

- Containment - the development and application of new or improved refractory materials in ladles and tundishes to improve the efficiency of ladle metallurgy and reduce potential contamination of the steel.

Projected New Process Technology Applications:

The trend is for greater use of ladle metallurgy and vacuum degassing technology in integrated steel plants. This trend is likely to accelerate as further demands are made for improved quality. When a continuous steel-making process has been developed and applied to an integrated steel plant, there will be a further major expansion in the application of ladle metallurgy and vacuum degassing technologies.

2.2.5 Teeming

After a heat of steel is properly refined in an oxygen steel-making furnace, in an electric arc furnace or by ladle metallurgy process, the liquid steel may be tapped into ingot moulds.

The ladle, carried by an overhead crane, is positioned over the ingot moulds one by one and the molten steel is poured through a refractory nozzle in the bottom of the ladle. The ingot moulds are tall box-like containers made of cast iron. The mould cavity for receiving the molten steel is usually tapered from top to bottom primarily to facilitate stripping and is designed for specific shapes and sizes of ingots. A refractory ring is placed on the top of some types of ingot moulds to provide a reservoir of hot metal above the ingot mould, producing an ingot with no or less shrinkage in the body of the ingot. Mould coatings are sometimes applied to the interior surface of the mould to reduce the formation of surface imperfections of the ingot.

The moulds are left to cool and then are stripped. The refractory hot top is removed and discarded as waste, and the ingot is lifted out of the mould and transferred to the soaking pits in the hot mill for further processing.

The use of ingots is decreasing as more steel is continuously cast. In new plants teeming of ingots is carried out only when the continuous casting machine cannot accept a heat of steel for some reason, so the teeming facility is included in the plant for emergencies only.

2.2.6 Continuous Casting

2.2.6.1 Continuous Casting Process

Continuous casting is a process whereby molten steel is poured into a water-cooled mould on a continuous basis and the desired solid steel shape exits from the process. The development of the continuous casting process for steel started before 1900, but the first commercial applications occurred in the early 1950s. The first continuous casting machines for steel were vertical machines, the cast shape being in the vertical position when the shape was cut to length. The modern machines bend the steel shape into the horizontal position before cutting to length.

The continuous casting process has reduced the number of operations required for the production of steel. Typically, the sequence of operations without continuous casting was:

(1) Tapping liquid steel from a steel-making furnace into a ladle.
(2) Transferring the ladle to the pouring platform and teeming liquid steel into ingot moulds.
(3) Transferring filled moulds to the stripping area for ingot removal.
(4) Transferring and charging ingots into soaking pits and heating to rolling temperature.
(5) Removal of heated ingots from soaking pits and transfer to primary rolling mill for rolling into semi-finished shapes.
(6) Transferring semi-finished shapes to subsequent rolling mills.

Using continuous casting, the following much shorter sequence of operations is required:

(1) Tapping of liquid steel from a steel-making furnace into a ladle.
(2) Transferring the ladle to a casting platform and continuously casting liquid steel into semi-finished shapes.
(3) Transferring the semi-finished shapes to rolling mills.

The benefits derived from continuous casting include:

Increased yield - Increased yield from liquid steel in the ladle to the semi-finished rolled shape results from a reduction in scrap and scale losses in three areas: the primary rolling mill, the pouring operation (primarily elimination of top and bottom ingot crop losses), and the soaking pits (primarily scale losses). The process yield is more than 95 percent for continuous casting compared with approximately 80 percent for the production of semi-finished products from ingots.

Improved quality - An improved, more uniform finished product can be obtained with fewer internal and surface defects.

Energy savings - Energy savings are achieved with continuous casting because of the elimination of the energy-consuming steps in the ingot process. Also, a large proportion of the energy contained in the molten steel is retained in the semi-finished product, thus requiring less energy for reheating prior to rolling.

Pollution - Continuous casting reduces pollution through the elimination of ingot processing facilities such as soaking pits and the primary rolling step.

Costs - Both capital and operating costs are reduced.

Productivity - Productivity improvement is achieved through the reduction in manpower required and the shortening of the elapsed time required to produce semi-finished steel from liquid steel.

The ladle of molten steel from the electric arc furnace, basic oxygen furnace or ladle metallurgy process is hoisted to the top of the continuous casting machine and placed on a support platform above the caster tundish. Most new continuous casting machines incorporate a ladle swivel mechanism so that casting can be switched from one ladle to another without interrupting the cast. The molten steel is poured from the ladle through a refractory nozzle in the bottom of the ladle into the tundish. The tundish is a small refractory-lined vessel that acts as a reservoir with a refractory pouring nozzle in the bottom equipped with a stopper rod mechanism for flow control. Separation of entrained slag and inclusions is facilitated in the tundish and the slag is periodically removed. The molten steel then pours into the mould below the tundish. The molten steel streams between the ladle and the tundish. The tundish and the mould are commonly protected by refractory tube shrouds, using nitrogen or argon as a protective gas to protect the molten stream from contact with the air to prevent oxidation.

The mould is constructed as an open-ended box structure containing an inner lining fabricated from a copper alloy which serves as the interface with the steel being casted and provides the desired shape to the cast section. The shape is designed for the desired product. Common shapes are for slabs (up to 2.2 metres by 300 mm), blooms (up to 400 mm by 600 mm), billets (up to 150 mm square) and rounds (up to 210 mm in diameter). Some special shapes are also cast (eg. beam blanks which are subsequently rolled into I beams). Some moulds are straight while others are curved to reduce the height of the casting machine. The mould is internally water cooled and is designed so that the steel shape leaves the mould with a solid skin.

The moulds oscillate and have a mould lubricant to prevent the solidifying steel from sticking to the mould surface.

In modern casting machines, secondary cooling, strand containment and withdrawal form a closely integrated and interlocked system which also includes strand bending and straightening. This is more pronounced for slab casting than for other shapes. The secondary cooling is by direct water sprays located between the containment rolls. The strand is contained by a series of containment rolls which extend across the two opposite sides of the strand in a horizontal direction. Edge rollers are also usually used, especially for blooms and billets, to contain the other two sides of the strand. Once the strand is fully solid, the rolls bend the strand through a radius to the horizontal direction and then straighten the strand. Drive rolls are interspersed with the containment rolls for withdrawal of the strand. The straightened strand is then cut to the desired length, usually by oxygen torches although the smaller sections may be sheared. The slag generated by the torch cutting is carried by water down the flume to a slag pit. The cut-to-length strands are then conveyed by roller table to reheating furnaces prior to rolling. In modern steel plants the continuous-casting machine is usually located very close to the rolling mill to minimize heat losses.

2.2.6.2 New Technology Developments

The major new technology development in continuous casting is the evolution of "near net shape casting". Several processes have been developed for near net shape casting including:

- single roll (melt drag and spray deposition)
- twin roll
- twin belt
- wheel-belt (billets)
- single belt (mould-trough train and spray deposition)
- convex mould/conventional equipment

Most of this work is being carried out to produce thin slabs and, eventually, strip. One main objective is to eliminate the hot-rolling mill and provide a semi-finished material that requires cold rolling only.

One commercial thin slab continuous-casting machine has recently started operations. However, the product is limited to a thickness of between 25 and 38 mm and a width of 1300 mm.

The major challenges still facing the development of near net shape casting include:

- production rate - The very low production rates achieved to date must be drastically increased for commercial carbon steel production.
- metal delivery - The metal must be delivered to the caster in a controlled manner while avoiding re-oxidation.
- metal containment -New methods must be developed to maintain the metal at the edges.
- surface quality - Surface quality must be improved.

Other continuous-casting technology developments are in the area of evolutionary improvement of the existing process such as process control, product quality improvement and productivity improvement.

The most likely application of new technology is the application of near net shape casting to a broad range of products, especially flat products.

2.3 Hot Forming

2.3.1 Reheating

A heating furnace is utilized to raise the temperature of steel to prepare it for hot working. Heating furnaces are divided into two general classes:

1. Soaking pit furnaces

2. Reheating furnaces

The function of soaking pits and reheating furnaces is to raise the temperature of steel in the course of processing until it is plastic enough for economic reduction by rolling to the desired section.

2.3.1.1 Soaking Pit Furnaces

Since today more steel is continuously cast, a process which by-passes the soaking pits, the use of soaking pits has declined and in a modern plant only a few, if any, would be installed for emergencies or special cases.

The function of the soaking pit is to provide uniform heating of ingots to the desired temperature with a minimum of over heating of the surface. A soaking pit is a refractory-lined rectangular structure with a moveable cover. The soaking pits are heated by the combustion of a gaseous fuel, such as natural gas, or by oil. A recuperator is used to preheat the combustion air and to increase the thermal efficiency of the soaking pit. The cold ingots are received from the melt shop and are lowered into the soaking pit by a set of tongs mounted on the overhead crane. The soaking pit is brought up to temperature and held at temperature for a period of time to heat the ingots uniformly with a minimum of temperature difference between the surface and the centre of the ingot.

Once the ingots are at the desired temperature they are ready for rolling. The cover is retracted sufficiently for the crane tongs to pick up one ingot and transfer it to the ingot buggy. To conserve energy the cover is closed as soon as the ingot leaves the soaking pit. The burners are shut off while the cover is open. The ingot buggy runs on tracks to the mill approach table and positions the ingot on the mill approach table.

2.3.1.2 Reheating Furnaces

Reheating furnaces are divided into two general classes:

1. Continuous type - including pusher type, rotary-hearth type, walking-beam type, walking-hearth type and roller-hearth-type.

2. Batch type.

Continuous furnaces are those in which the charged material moves through the furnace and is heated to rolling temperature as it progresses. Again, the furnace is a refractory-lined rectangular structure heated by oil or gas, with the exception of the rotary-hearth furnace which is circular in shape. Recuperators are used to preheat the combustion air and to increase energy efficiency.

Reheat furnaces usually have one of two functions: to heat semi-finished steel from room temperature to rolling temperature or to increase the temperature of insufficiently heated steel, such as continuously cast shapes. Continuously cast shapes are usually transferred as quickly as possible from the continuous casting machine to the reheat furnace to increase energy efficiency. In some cases, however, they are cooled for surface condition and must then be reheated from room temperature.

The main difference between the various types of continuous reheat furnaces is in the method by which the material is moved through the furnace.

Pusher-Type Furnaces - The steel to be heated is charged into the furnace either through a side door or through the end of the furnace. In either case, the steel is moved through the furnace by pushing the last piece charged with a pusher at the charging end. As each cold piece is pushed into the furnace against the continuous line of material, a heated piece is removed and transferred to the rolling mill by roller conveyor. This type of furnace is used for billets and slabs.

Rotary-Hearth Furnaces - As the name implies, the hearth of this furnace rotates. The cold pieces are charged into the furnace and are heated as the furnace hearth rotates. The heated pieces are mechanically removed from the furnace and placed on the discharge conveyor. This type of furnace is used primarily for heating rounds in tube mills or short billets and blooms for forging.

Walking-Beam-Type Furnaces - These furnaces use a water-cooled steel beam, topped with refractory, that lifts the pieces of steel and moves them forward one space and retracts below the hearth to move backwards to lift the pieces of steel for the next forward movement. In charging, the pieces of steel are placed on the walking beam ends by a conveyor outside the furnace. The walking beam also places the hot pieces on the discharge conveyor for transfer to the rolling mill. This type of furnace is widely used for heating slabs, billets and blooms.

Walking-Hearth-Type Furnaces - The travel of the pieces of steel through this furnace is similar to the walking-beam furnace. The major difference is that the steel is supported on refractory piers above the hearth of the furnace and the hearth moves similar to the walking beam. This type of furnace is used for heating slabs, billets and blooms.

Roller-Hearth Reheating Furnaces - In this type of furnace the steel moves longitudinally through the furnace on water-cooled, refractory coated rollers. This type of furnace has not been widely used to reheat steel for rolling, but the advent of continuous casting has prompted studies on its use for longer lengths of continuously cast slabs.

Batch furnaces are those in which the charged material remains in a fixed position until heated to rolling temperature. They are primarily used for speciality steels and forgings and are not considered for tonnage steel operations.

2.3.2 Surface Preparation

Semi-finished steel is an intermediate product that has been continuously cast or previously hot-worked. The semi-finished steel may have surface defects that originated in earlier processing steps and which must be removed to ensure satisfactory surface quality of the finished steel product. These surface defects may originate in the ingots, during heating in the soaking pits or in the primary rolling operations for steel produced from ingots or from the continuous-casting process or reheat furnaces. Surface defects are usually removed by a mechanical process such as chipping or machining or by scarfing with oxygen torches. Chipping is not widely used in a tonnage steel mill. Some semi-finished steel, such as blooms and billets, may be machine conditioned using a specially-designed milling machine or grinder. Machine conditioning is more widely used in the higher-alloy grades of steel since the material loss can be more closely controlled than with machine scarfing.

The most common process used is scarfing. Some semi-finished steel is hand-scarfed with oxygen torches. In this process the steel is cooled prior to scarfing. The scarfing operator, using a hand-held scarfing torch, melts the defects out of the surface of the steel.

Machine scarfing is more widely used for tonnage steel mills and is located in front of the rolling mill. A series of scarfing torches scarfs a thin surface layer off all four sides of the semi-steel product. This results in a material loss of 1 to 3 percent depending on the depth of the scarfing. The slag from the scarfing is removed from the scarfed surface before the work piece leaves the scarfing machine.

2.3.3 Hot Rolling

Rolling is the most common process used to convert raw steel - whether ingots or continuously cast products - into intermediate and final products. In simple terms, hot rolling is the process of passing a piece of hot steel between two rolls with the objective of reducing the thickness of the steel. The most common types of hot-rolling mills used in the integrated steel plants are primary mills, plate mills, hot strip mills, bar and rod mills, section mills and tubular product mills.

A further distinction between the types of mills is that of the number of rolls contained in one stand - two-high, three-high or four-high. A two-high mill has two rolls, one directly above the other rotating in opposite directions, a three-high mill has three rolls, again directly above one another with the two lower rolls rotating in the opposite direction and the top roll rotating in the same direction as the middle roll and a four-high mill has four rolls directly above one another with the work piece entering between the two middle rolls and the upper and lower rolls providing structural support to the middle rolls.

2.3.3.1 Primary Mills

The primary rolling mills are used to roll ingots into semi-finished products such as slabs, blooms and billets. Slabs are always oblong in shape and usually range from 50 to 230 mm thick by 610 to 1520 mm wide. Blooms are square or slightly oblong in shape and usually range in size from 150 mm by 150 mm to 300 mm by 300 mm. Billets are mostly square and mostly range in size from 50 mm square to 125 mm square. Some continuously-cast, semi-finished steel may also be rolled on a primary hot mill. There is no standard configuration for a primary hot mill.

One configuration is a single stand, multiple purpose, two-high reversing mill where the ingot is moved back and forth through the mill with a reduction in the thickness of the work piece during each pass. This type of mill can be used for a variety of semi-finished products. Another configuration is a two-high tandem mill. In this configuration a group of two-high mills is installed in series with space between them for the workpiece which travels through the mills in sequence with each mill further reducing the thickness of the work piece.

A three-high mill is usually a single stand mill for the smaller sizes of semi-finished steel. The work piece is rolled in one direction between the two lower rolls and then in the opposite direction between the two upper rolls. The mill does not have to reverse the direction of the rolls to roll the work piece in the opposite direction.

The work pieces are transported between the mill stands by roller tables. Moveable side guards are used to guide the work piece into the rolls at the correct location and to prevent the work piece from skewing as it passes through the mill stand. Mechanical manipulative devices are used to turn the work piece over or on edge as required. In some cases a set of edger rolls is located at some of the stands, especially for slabbing mills, to maintain the proper shape of the edge of the slab. Shears are used to cut the semi-finished product to length and to crop the deformed ends. Depending on the mill practice and the grade of steel, the semi-finished product may be transferred to a finishing hot mill or cooled for conditioning or annealing prior to finish rolling.

2.3.3.2 Plate Mills

The typical sequence of operations for plate mills is:

1. Scarfing or slab preparation
2. Heating slabs for rolling
3. Descaling
4. Rolling
5. Levelling or flattening
6. Cooling
7. Shearing or cutting

Steps 1 and 2 were discussed in sections 2.3.1 and 2.3.2.

The heated slabs are de-scaled using high-pressure water jets prior to entering the mill. The mill types vary according to the mill design, the product being rolled and the desired production level. The rolling process is similar to that described in the primary mill section (p. 2.3.3.1). After the steel plate is reduced to the thickness specified, it is flattened in a roller leveller, cooled to an intermediate temperature, sheared or torch-cut to size and final cooled. Powered roller tables are used to transport the work piece to and from the rolling mill(s) and to the roller leveller and shears.

2.3.3.3 Hot-Strip Mills

The typical modern wide hot-strip mill consists of a roughing scale-breaker, three to five four-high roughing stands, a finishing scale-breaker and five to seven four-high finishing stands. Most of the roughing stands are equipped with an integral vertical edger in front of each stand. High-pressure water sprays to remove the scale are located after scale-breakers and sometimes at one or more of the roughing stands.

The slab enters the first roughing stand and is progressively reduced in thickness as it passes through each of the stands. The work piece is transported to the mill and between the stands by roller conveyor tables.

A crop shear is usually located in front of the first finishing stand to trim the entry and exit ends of the work piece. Typical finished hot strip sizes range from a thickness of 1.2 to 13 mm and widths of 600 to 2450 mm. As the strip proceeds from the final stand of the mill, it is carried over the runout table where water is applied to the top and bottom of the strip for controlled cooling of the strip. The strip is then coiled in a coiler and the coils of steel are transported to the cold mill for cold finishing or to shipping.

2.3.3.4 Bar and Rod Mills

The bar mill is used to roll billets to various shapes and sizes. A typical bar mill will use a combination of rolling mill stands starting with roughing mills, often in a semi-continuous arrangement, followed by finishing mills, usually in a continuous arrangement. The rolling mills are usually two-high although some mills may employ a three-high roughing stand in addition to a number of two-high roughing stands. Often there will be as many as 16 mill stands. Shears are included in various locations of the mill to trim the bar ends as required and to cut the product to length. Cooling tables (air-cooled) are provided to cool the product before inspection and further processing or shipping. When the bar mill includes a final group of stands and a coiler to produce wire rod, it may be know as a rod mill.

A typical bar mill range of products can include:

Rounds	9.5 to 65 mm
Squares	9.5 to 50 mm
Hexagons	9.5 to 50 mm
Flats	13 to 100 by 5 to 38 mm
Reinforcing bars	9.5 to 43 mm
Cut lengths	1.5 to 28 metres
Rod coils	230 to 1900 kg

2.3.3.5 Section Mills

Section mills roll a range of structural shapes. The rolls used in the section mills have the shape profile machined into the face of the roll. The shape starts as a minor change to the bloom and becomes progressively closer to the final shape with the shape profile in the final roll being that of the desired shape.

A typical section mill will have a combination of a two-high reversing roughing stand followed by several three-high intermediate stands and either a two-high or a three-high finishing stand. The product is hot sheared or saw-cut to length, cooled and straightened for shipping.

2.3.3.6 Tubular Product Mills

The sequence of operations in seamless-pipe mills varies slightly from mill to mill and according to the pipe size. Typically, round billets are heated and pierced in a piercing mill. A pair of rolls at an oblique angle forces the steel in the billet to flow around the piercing mandrel. The hollow shell is withdrawn from the mandrel, reheated and forced over a series of mandrels, one at a time, until the proper size and wall thickness have been attained.

Application of New Technology to Hot-rolling:

The most likely change in hot-rolling technology is the adoption of near-net-shape, continuous-casting processes, especially for flat products. This technology will enable smaller steel plants to make a wider range of products without the large capital-intensive hot-rolling mills and enable integrated steel plants to continue to produce large tonnages of hot-rolled products with smaller less-capital intensive hot-rolling mills.

2.4 Cold Forming

2.4.1 Cold Rolling

Cold working by cold rolling consists of passing unheated, previously hot-rolled bars, sheets or strip (cleaned of scale) through a set of rolls, usually many times, until the final size is obtained. In an integrated basic steel plant the major cold-rolled products - and sometimes the only ones - are sheet and strip.

The hot-rolled coil is cleaned and annealed prior to cold rolling. It is reduced in thickness between 25 and 90 percent in the cold-rolling operation. The most common type of cold-rolling mills is the multi-stand, four to six stands, continuous type where the hot-rolled coil is reduced in thickness in one pass of the material. The heavy thickness reductions at high speed generate considerable heat and raise the temperature of both the steel sheet and the rolls. The heat generated is dissipated by a system of flood lubrication in which a mixture of oils is directed in jets against the roll bodies and the surface of the steel. Some mills use palm oil on the steel and high pressure on the rolls.

After the major reduction in thickness has been accomplished, the steel sheet, in coil form, is prepared for shipping or is further reduced in single or multi-stand mills where the final reduction is accomplished. In these mills the degree of reduction is much less and is designed to impart the desired surface finish and quality to the steel.

2.4.2 Acid Pickling

The hot-rolled steel coils have a coating of rust and mill scale when they are received from the hot mill. This surface coating has to be removed prior to cold rolling to avoid rolled-in surface imperfections. Although mechanical cleaning methods have been used, acid pickling is the only process now used for high volume operations. The hot-rolled steel coils are mounted on a coil unwinder and the leading edge is welded to the end of the previous coil to maintain a continuous ribbon of steel traversing the acid pickling operation.

The steel is moved through a series of tanks containing acid. Sulphuric acid was the most common acid used for sheet pickling and is still used in many applications today. However, hydrochloric acid is more commonly used in new plants since use increases productivity and line through-put. New hydrochloric acid regeneration processes have been developed which eliminate the need for disposal of the spent pickle liquor and reduce the volume of acid that has to be purchased. The mill scale and rust are removed from the steel surface by the chemical action of the acid.

The steel sheet then passes through a series of water rinse tanks to remove the traces of acid adhering to the surface. The steel coil is rewound on a coil rewinder and is transferred to the cold-rolling mills for further processing.

2.4.3 Alkaline Cleaning

Alkaline cleaning is used to remove mineral and animal fats and oils from the steel surface. The operation is similar to that of acid pickling except for the cleaning agents that are used. The most commonly used cleaning agents are phosphates, alkaline silicates, caustic soda and soda ash. Electrolytic cleaning is also used in some cases.

The cleaning agents are generally classified as highly silicated (18 to 28 percent SiO_2), medium silicated (6 to 11 percent SiO_2) or slightly silicated (2 to 3 percent SiO_2). The non-silicated cleaning agents can be classified by their phosphate content, high phosphate (8 to 12 percent P_2O_5), medium phosphate (4 to 7 percent P_2O_5) or non-phosphated. Other agents such as wetting agents may be added.

The coils of steel sheet are passed through the cleaning tanks where the cleaning reagent is usually agitated for improved performance. The sheet is passed through rinse tanks and recoiled for further processing.

2.4.4 Annealing

The cold-rolling action increases the hardness and changes the size and shape of the crystalline structure of the steel. Annealing is required to remove the hardness and change the grain structure and size.

Continuous annealing is carried out by passing the sheet through a multi-zone heating furnace. The steel temperature is raised to between 730 °C and 830 °C and then cooled by gas jets, gas-water sprays, contact rolls or water quench depending on the desired metallurgical properties. These furnaces are usually heated by gas, directly or indirectly, or electricity and the steel may be protected by an inert or reactive atmosphere in part of the furnace. Dry reducing atmospheres are often used for this application and may be a mixture of hydrogen and nitrogen or disassociated ammonia.

Box-annealing is carried out by placing one or more coils of steel on a furnace base and then setting the furnace shell on the base enclosing the coils. Heating is similar to that of continuous annealing and either gas or electricity is used. Protective or reducing atmospheres are usually used. The coils may be furnace cooled or removed from the furnace for other forms of cooling.

Open-coil annealing is similar to box-furnace annealing except that the coil is rewound with a space between each wrap of the coil to increase the heat transfer and provide more uniform heating.

2.4.5 Coating

Some of the steel is coated for corrosion protection. The most common coatings in an integrated basic steel plant are zinc, aluminum, terne metal (lead-tin alloy) and zinc-aluminum. The common continuous coating process for sheet is hot-dip galvanizing consisting of a coil un-winder, a cleaning section to remove oil and other contaminants, an annealing section (sometimes), a hot-dip section where the steel sheet is passed through a molten metal bath, a heating section for galvannealing (sometimes) and a passivation section (sometimes).

Electro-galvanizing is also used in some plants.

2.5 Utilities

2.5.1 Water Preparation and Distribution

An integrated basic steel plant consumes large quantities of water. In the past water consumption for steel production varied between 6,000 and 180,000 litres per tonne of steel. In modern plants water recycling is practised and in some cases water consumption is below 4,000 litres per tonne. About two-thirds of the water usage is for indirect cooling and one-third for process use.

The water preparation process depends on the quality of the water supply and the use to the treated water. In most locations the water is screened to remove suspended material and may be filtered if higher quality is required. In the case of some steel plants located on tide water, salt water may be used for some applications, especially if there is a shortage of fresh water.

Further treatment, including softening, is often required for specific uses such as boiler feed water.

Potable water for human consumption is usually purchased from a local municipality if available. In a few cases the steel plant will operate a small potable water operation.

The water is pumped through pipe lines to the various user operations and the plant will often have a reservoir, underground or overhead, for emergencies and reserve.

2.5.2 Steam Generation and Distribution

The steam turbines that power the turbo-blowers for the blast furnace wind are the largest consumers of steam in an integrated basic steel plant. Other large users include the turbines driving the coke oven gas exhausters and boosters, steam-driven auxiliaries in the boiler house and some plant processes.

In some plants steam is also used to generate part of the steel plant's electricity.

Large power boilers are used to generate the large quantities of steam required for a steel plant. The boilers for an integrated steel plant are usually multi-fuel and use blast furnace and coke oven gas. Many also use fuel oil to supplement the gaseous fuels. The boiler house is used to balance fuel consumption in the plant to ensure that a minimum, if any, of the gas is not consumed in the steel plant.

The steam is distributed to the user operations by pipeline.

2.5.3 Fuel Storage and Distribution

Fuel oil, when used, is stored in tanks near the major users and is distributed by pipeline. With the increased use of continuous casting and other energy-conserving practices, the use of fuel oil has declined.

Blast furnace gas, due to its low energy content and pressure, is used for only the blast furnace stoves, coke oven under-firing and steam generation. It is distributed through large-diameter pipelines and a large gas holder is used to even out fluctuations between supply and demand.

Coke oven gas is usually used for coke oven under-firing, blast furnace stoves and steam generation. In some plants part of the coke oven gas is also used in reheating and annealing furnaces. Although much of the coke oven gas was used in a raw state in the past, modern practice is to use only cleaned gas. The coke oven gas is distributed through pipe lines and a gas holder is used to even out fluctuations between supply and demand. In some cases where the coke oven gas is widely distributed in the plant the gas pressure is increased by the use of a turbo-booster.

Natural gas is used for some operations in many steel plants, especially where a high-quality fuel is required. In some plants natural gas is blended with coke oven gas to provide a mixed fuel of higher energy value than coke oven gas. The natural gas is distributed by pipe line.

2.5.4 Process Gases (eg. Oxygen, Nitrogen) Production, Storage and Distribution

The major process gas used is oxygen for the basic oxygen furnace steel making. Approximately 57 m^3 of oxygen is consumed per tonne of steel produced with 80 percent of oxygen used for the basic oxygen steel making. Other uses include enrichment of the blast furnace blast, scarfing, electric furnace lancing and plant maintenance.

About 10 percent of the oxygen is produced by the steel companies with the balance being produced by outside companies both on-site and off-site. All of the tonnage oxygen is produced by fractional distillation processes. The oxygen is distributed by pipeline and some bulk storage is usually in place adjacent to the steel making shop.

Nitrogen is often used, especially in annealing operations, and is usually distributed by pipeline from bulk storage. Where a tonnage oxygen plant is located within or near a steel plant, some by-product nitrogen may be piped to some of the users.

3.0 POLLUTANTS GENERATED BY PRODUCTION PROCESSES

3.1 Iron Making

3.1.1 Raw Material Handling and Storage

3.1.1.1 Wastewater

Wastewater discharge from the raw material handling and storage originates from precipitation. The volume of wastewater generated varies according to precipitation and the area covered by the storage piles. The major pollutant from raw material storage is suspended solids although there may be low concentrations of other pollutants present, such as oil from the dust suppression of coal storage piles. There will also be a small volume of wastewater from the rail car washing operation.

3.1.1.2 Air Emissions

The majority of emissions of air pollutants are from the action of wind on the storage piles and are particulate matter. Other sources include the residual particulate emissions from the material handling equipment and the dust generated by the action of mobile material handling equipment. Emission factors for the fugitive road dust emissions are calculated on a site-specific basis as outlined in EPA's documents: "User's Guide Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions, EPA/625/5-87/022" and "Control of Open Fugitive Dust Sources, EPA 450/3-88-008, September 1988".

Particulate emission rates for raw material handling and storage are shown in Tables 3.1.1.1 and 3.1.3.5.

A small quantity of NO_x emissions will also be generated by the rail car thawing operation in the winter time.

TABLE 3.1.1.1 EMISSION RATES FOR RAW MATERIALS HANDLING AND STORAGE

Process or Operation	Basis for Emission Measurement	Uncontrolled Emission Rate
Iron ore handling and storage	kg particulate per tonne hot metal	0.28
Pellet handling and storage	kg particulate per tonne hot metal	0.01
Coal handling and storage	kg particulate per tonne coal used	0.06

Source: Handbook of Air Pollution Technology, John Wiley & Sons 1984

3.1.1.3 Solid Waste

One form of solid waste is the fine material left after the storage is depleted. Since this material is covered by the material added to the storage, no net waste material is generated. The other form of solid waste is the solids collected from the run-off water. This is usually recycled with the virgin material.

3.1.2 Sintering (Beneficiation)

3.1.2.1 Wastewater

Sintering wastewaters result from dust and scrubbing equipment, from water cooling and from quenching of the sinter. Many of the newer sintering plants are equipped with "dry" air pollution control systems which eliminate any water discharge from the air pollution control systems. Normally there is no water discharge from the sinter quenching operation although the recycling of oily mill scale may require wet scrubbing to minimize oil fume emissions. Non-contact process cooling water is not contaminated (except by the increase in temperature) although there is a small blowdown stream where cooling towers are used.

Typical pollutant concentrations for wastewater from sinter plants using wet scrubbing are shown in Table 3.1.2.1. Small quantities of cyanides, chrysene and fluoranthene may also be present.

TABLE 3.1.2.1 RAW WASTEWATER POLLUTANT CONCENTRATIONS FOR SINTER PLANT OPERATIONS (with wet scrubbing)

Pollutant	mg/L
Flow	400 to 1200 L/tonne
pH (units)	6 - 12
Ammonia (N)	5
Fluoride	1 - 20
Oil and grease	10 - 200
Phenols (4AAP)	0.5 - 2
Total suspended solids	500+
Cadmium	0.05 - 1
Chromium total	0.01 - 0.2
Copper	0.1 - 0.6
Lead	0.2 - 6
Nickel	<0.2
Zinc	0.5 - 8

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume II Sintering Subcategory, EPA 440/1-82/024, May 1982

Solids originate as particulate generated by the sintering operation and collected by the wet scrubbing system. Fluorides and metals originate from the iron ore being sintered and are collected by the wet scrubbing system. The concentration of fluorides and metals is dependant on the concentration in the iron ore being sintered.

3.1.2.2 Air Emissions

In the sintering process air emissions are from the combustion of the fuel, which carries substantial quantities of particulate out of the windbox, and from the cooling air circulating through the sinter strand and discharge. Particulate emissions are also generated in the sinter crushing and screening operations.

Nitrogen oxides and hydrocarbon emissions are generated by the combustion process although the emissions of nitrogen oxides are somewhat reduced by the nature of the sinter strand combustion system. Limited sulphur dioxide emissions are present from the oxidation of sulphur compounds in the solid fuel (usually coke breeze and coal) and any sulphur compounds that may be present in the iron ore. Typical SO_2 emissions range up to 1200 mg/Nm^3.

The recirculation of sinter fines and the sintering of various steel plant iron-bearing dusts increase the particulate loadings to the air pollution control equipment, especially if oily mill scale is recycled. Emission rates for the sintering process are shown in Table 3.1.2.2.

Particulate emissions may contain cadmium, arsenic, chromium, copper, nickel, lead and zinc depending on the concentration in the raw materials. Emissions of fluorides, both gaseous and particulate, occur if they are present in the raw materials. Some emissions of hydrocarbons are generated from the solid fuel and are increased if oily scale is recycled. There is limited data available on the emissions of these pollutants and this is summarized in Table 3.1.2.3.

Fugitive emissions are generated by non-enclosed materials handling (particulate) and incomplete capture of process emissions by the collection system (particulates and SO_x).

3.1.2.3 Solid Waste

Solid waste is generated by the collection of particulate matter from the air pollution control equipment and fines from the crushing and screening of the sinter. The solid waste is recycled in the sintering process so that no solid waste is discharged from the process.

TABLE 3.1.2.2 AIR EMISSION RATES (UNCONTROLLED) FOR THE SINTERING PROCESS

Process or Operation	Basis for Emission Measurement	Pollutant	Emission Rate (1)	Emission Rate (2)
Sinter windbox	kg/tonne of sinter produced	Particulate SO_x NO_x HC CO	4.35 22	2.2 0.9 0.6(3) 0.12
Sinter discharge	kg/tonne of sinter produced	Particulate	3.4	3.5
Sinter building fugitives	kg/tonne of sinter produced	Particulate	0.35	
Sinter crushing and screening	kg/tonne of sinter produced	Particulate	0.10	

Source: (1) Compilation of Air Pollutant Emission Factors Volume 1: Stationary Point and Area Sources, Fourth Edition, Supplement B, AP-42, September 1988

(2) Handbook of Air Pollution Technology, John Wiley & Sons, 1984

(3) NKK, Outline of Environmental Countermeasures at the Keihin Works

TABLE 3.1.2.3 CRITERIA AND TOXIC POLLUTANT EMISSION FACTORS (UNCONTROLLED) FOR THE SINTERING PROCESS

Operation	VOC	Manganese	Copper	Cadmium
	(g/tonne sinter)			
Windbox	700	67	2	1
Sinter processing	25	40	1.5	...

Source: Emission Factors for Iron and Steel Sources -- Criteria and Toxic Pollutants, EPA-600/2-90-024, June 1990.

3.1.3 Coke Production

3.1.3.1 Wastewater

The most significant wastewaters generated during by-product coke-making and by-product recovery operations are excess ammonia liquor (flushing liquor), final cooler wastewater, light oil recovery wastewaters, barometric condenser wastewaters from the crystallizer, sulphur removal system wastewaters and wastewaters from wet-type air pollution control systems. In addition, miscellaneous wastewaters result from coal and coke pile run-off, overflows from sumps and leaks from pumps, piping or other equipment. The wastewater generated from most of these operations can be minimized using modern process design and a high level of water recycle.

Typical wastewater flow rates from by-product coke-making are shown in Table 3.1.3.1.

The wastewater generation data were derived by EPA from plant sampling visits and questionnaires and are based on the process technology in use at that time.

Typical pollutant concentrations obtained at the same time for various sources are shown in Table 3.1.3.2.

Suspended solids originate, in part, as particulates of condensed tars, naphthalene crystals and particles of fine coal or coke which are carried out with the coke oven gas and are then trapped in the flushing liquor. When lime is used for fixed ammonia distillation columns, the sludge that is formed is another source of suspended solids. Biological treatment of coke-making wastewater also generates suspended solids.

TABLE 3.1.3.1 TYPICAL PROCESS WASTEWATER FLOW RATES FOR BY-PRODUCT COKE-MAKING

Wastewater Source	Flow (L/tonne coke)
Excess Ammonia Liquor	120 - 130
Final Cooler Blowdown	35 - 40
Benzol Plant Wastewater	95 - 100
Miscellaneous Process Wastewaters	75 - 80
Steam Condensate	50 - 55
Barometric Condenser Blowdown	35 - 40
Wet Desulphurizer Wastewater	130 - 140
Dilution Water (Bio-treatment Only)	170 - 180
Air Pollution Control Blowdowns (Wet-type scrubber systems)	0 - 220
Total Effluent Flow	710 - 985

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume II Coke Making Subcategory, EPA 440/1-82/024, May 1982

Oils and greases are organic compounds formed during the destructive distillation of coal. Ammonia and ammonia compounds are also formed during the coking process from the nitrogen present in the coal while sulphur compounds are formed from the sulphur contained in the coal. Numerous other organic compounds are formed by the destructive distillation of coal and some of these compounds are subsequently found in the wastewater streams. The coke oven wastewater has a high pH due to the ammonia in the various wastewater streams and from the lime used in the fixed leg of the ammonia still.

In addition, EPA sampled for a wide range of other pollutants. These are summarized in Table 3.1.3.3.

TABLE 3.1.3.2 RAW WASTEWATER POLLUTANT CONCENTRATIONS FROM BY-PRODUCT COKE-MAKING OPERATIONS (1)

Pollutant	Excess Ammonia Liquor	Final Cooler Blowdowns	Quenching	Barometric Condenser Wastewater
pH, (Units)	8.5	8.2	7.2	8.7
Suspended Solids	183	40	302	35
Oils & Greases	100	189	1.2	8.5
Ammonia (N)	5189	100	0.1	0.3
Sulphide	569	289	0	
Thiocyanate	428	8.7	0	
Cyanides	113	84	0	138
Phenolic Compounds	907	164	<0.1	2.7

(1) All values are in mg/L unless otherwise noted.

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume II Coke Making Subcategory, EPA 440/1-82/024, May 1982

The suspended matter in the coke plant wastewater is reported in Sweden to contain about 0.2 g/tonne of PAHs if the wastewater is not filtered. *

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* Source: Wradhe, Hans: National Environmental Protection Board, Sweden; 1990-04-24, Personal communication.

TABLE 3.1.3.3 NET CONCENTRATIONS OF SELECTED POLLUTANTS IN VARIOUS BY-PRODUCT COKE-MAKING RAW WASTEWATER STREAMS

Pollutant	Maximum Concentration (mg/L)	Wastewater Stream
Acrylonitrile	3.3	Excess Ammonia Liquor
Benzene	85	Benzol Plant
2,4-Dimethylphenol	6	Benzol Plant
2,4-Dinitrotoluene	5.3	Excess Ammonia Liquor
Fluoranthene	3.1	Excess Ammonia Liquor
Naphthalene	39	Final Cooler Blowdown
Phenol	413	Excess Ammonia Liquor
Phthalates, total	12.4	Benzol Plant
Benzo(a)pyrene	0.2	Excess Ammonia Liquor
Fluorene	2.5	Excess Ammonia Liquor
Pyrene	2.6	Excess Ammonia Liquor
Toluene	17	Final Cooler Blowdown
Xylene	145	Benzol Plant
Cyanides	188	Final Cooler Blowdown
Arsenic	0.7	Excess Ammonia Liquor
Copper	0.06	Excess Ammonia Liquor
Zinc	0.5	Excess Ammonia Liquor

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume II Coke Making Subcategory, EPA 440/1-82/024, May 1982

3.1.3.2 Air Emissions

Particulate, volatile organic compounds, carbon monoxide and other emissions originate from a number of by-product coking operations: (1) coal preparation, (2) coal preheating (if used), (3) charging coal into ovens incandescent with heat, (4) oven leakage during the coking period, (5) pushing the coke out of the ovens, (6) quenching the hot coke, (7) under-fire combustion stacks, (8) by-product plant leaks and spills and (9) storage of volatile hydrocarbons.

Gases collected from the ovens during the coking process are subjected to various operations in the by-product plant to separate ammonia, tar, phenol, light oil (benzene, toluene, xylene), pyridine, sulphur and, often, hydrogen cyanide from the coke oven gas and ammonia and other compounds from the flushing liquor.

Emissions from coal preparation usually consist of particulate emissions from the crushing, screening, blending and handling of the coal for charging. In plants using preheated coal, emissions are generated from the fuel used to preheat the coal together with particulate emissions from the coal itself.

Emissions from charging include particulate matter and volatile organic compounds from coal decomposition. During the coking cycle, volatile organic emissions from the thermal distillation process leak to the atmosphere through poorly sealed doors, charge lids and off-take systems, through cracks that develop due to the changing thermal stresses in the oven refractories and through leaks in the off-takes and collector mains.

A major source of emissions is the pushing step. Emissions from well-coked pushes consist mainly of particulate and carbon monoxide and carbon dioxide from the combustion of the outer shell of coke as it comes in contact with air. If the coke is not fully coked, the emissions also include volatile organic compounds. Particulate emissions continue to be generated, although at a much lower rate, until the quench car reaches the quench tower. Particulate from the coke is entrained in the rising steam plume from the quenching process. This plume may contain some volatile organic compounds as well. Particulate emissions are also generated from the crushing, screening and handling of the coke.

The gas combustion in the battery flues produces emissions through the combustion stack. These emissions include particulate matter contained in the fuel and carbon monoxide, carbon dioxide and nitrogen oxides from the combustion process. The nitrogen oxide emission factor for coke oven gas is considerably smaller than that for other fuels due to the lower calorific value of the coke oven gas used. The nitrogen oxide emission factor is further reduced when the coke oven gas is blended with blast furnace gas.

Sulphur dioxide emissions are generated by the combustion of the sulphur compounds in the coke oven gas, although these emissions are greatly reduced if the coke oven gas is desulphurized. If the oven refractories are damaged, coal fines and coking decomposition products also may leak into the combustion waste gases.

Fugitive-type emissions from the by-products section of the plant are much lower and originate from spills, leaks and storage tank vents. They contain volatile organic compounds including benzene.

Associated with the by-product coke production are open-source fugitive dust emissions from material handling, including the reclaiming and handling of coal, coke and coke breeze and from vehicles travelling on roadways within the plant.

The uncontrolled emission factors for coke manufacturing are contained in Table 3.1.3.4 and uncontrolled emission factors for benzene are contained in Table 3.1.3.5

TABLE 3.1.3.4 UNCONTROLLED EMISSION FACTORS FOR COKE MANUFACTURING (1)

Type of operation	partic -ulate	SO_2	CO	Volatile organics (2)	NO_x	NH_3
Coal crushing	0.2	-	-	-	-	-
Coal preheating	1.75	-	-	-	-	-
Wet coal charging	0.24	0.01	0.3	1.25	0.015	0.01
Door leaks	0.27	-	0.3	0.75	0.005	0.03
Coke pushing	0.58	-	0.035	0.1	-	0.03
Quenching	2.62	-	-	-	-	-
Combustion stack	0.16	2.0 (3)	-	-	-	-
Coke handling	0.015	-	-	-	-	-

Note: (1) Expressed as kg/tonne of coal charged.

(2) Expressed as methane.

(3) Sulphur content of coal is 0.8% by weight; about 33% of total sulphur in coal charged to oven is transferred to coke oven gas; about 40% of the coke oven gas is burned during under firing operation; gas used in under-firing has not been desulphurized.

Source: Compilation of Air Pollutant Emission Factors Volume 1: Stationary Point and Area Sources, Fourth Edition, Supplement B, AP-42, September 1988

TABLE 3.1.3.5 UNCONTROLLED BENZENE EMISSION FACTORS FOR COKE BY-PRODUCT PLANTS

Source	Emission factor (g benzene/tonne coke)
Cooling tower	
Direct-water	270
Tar-bottom	70
Light-oil condenser vent	89
Naphthalene separation	87
Naphthalene processing	20
Tar-intercepting sump	95
Tar de-watering	21
Tar decanter	77
Tar storage	12
Light-oil sump	15
Light-oil storage	5.8
BTX storage	5.8
Benzene storage	5.8
Flushing-liquor circulation tank	9
Excess-ammonia tank	9
Wash-oil decanter	3.8
Wash-oil circulation tank	3.8
Pump seals	10e
Valves	7e
Pressure-relief devices	4.5e
Exhausters	0.5e
Sample connections	0.9e
Open-ended lines	0.3e
Total (rounded)	510

Note: e estimated.

Source: Benzene Emissions from Coke By-product Recovery Plants - Background Information for Proposed Standards, EPA-450/3-83-016a, May 1984

PAH emissions from the coke plant operations are reported as 5 to 10 g/tonne of coke with approximately 2/3 from pushing and 1/3 from quenching. * PAH concentrations in collected particulate samples are shown in Table 3.1.3.6.

TABLE 3.1.3.6 PAH CONCENTRATIONS IN COKE-OVEN EMISSIONS

Compound	Concentration range (ug/g of sample)
Octahydroanthracene	9 - 70
Dihydrofluorene	14 - 30
Benzindine	7 - 107
Fluorene	15 - 272
Dihydrophenanthrene	80 - 587
Dihydroanthracene	22 - 233
2-Mehtylfluorene	9 - 99
Benzoquinoline	8 - 80
Acridine	32 - 173
Phenanthrene	164 - 2830
Anthracene	46 - 943
Mehtylphenanthrene	45 - 1020
Mehtylanthracene	85 - 1690
Ethylphenanthrene	58 - 1580
Ethylanthracene	49 - 1470
Fluoranthene	270 - 5980
Pyrene	206 - 4630
Methylpryene	31 - 1020
Benz[a]anthracene	105 - 5510
Methylbenz[a]anthracene	22 - 1670
Benzo[b,j,k]fluorathane	174 - 4110
Benzo[a]pyrene	122 - 2630
Perylene	22 - 702
Methylbenzo[a]pyrene	6 - 344

Source: Emission Factors for Iron and Steel Sources -- Criteria and Toxic Pollutants, EPA-620/2-90-024, June 1990, Table 4, pp 19 - 21.

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* Source: Wradhe, Hans: National Environmental Protection Board, Sweden; 1990-04-24, Personal communication.

3.1.3.3 Solid Waste

The major solid wastes and by-products generated in the coking process are coke breeze, tar, ammonia products, sulphur, light oil, ammonia still sludge and sludge from the biological treatment plant. The quantities of waste materials (taken from Table 2.1.3.1) are: coke breeze 50 - 100 kg/tonne coal, tar 30 - 45 litres /tonne coal, ammonium sulphate 10 - 145 kg/tonne coal and light oil 9.5 - 15 litres per tonne of coal. Approximately 5 kg of sulphur per tonne of coal is recovered if the coke oven gas is desulphurized using an elemental sulphur recovery process. Approximately 2.2 kg of 90 percent CaO is used per kg of fixed ammonia, thus producing sludge composed of lime salts.

3.1.4 Iron Production (Blast Furnace)

3.1.4.1 Wastewater

The most significant source of wastewater generated by the blast furnace operation is the cleaning and cooling of the raw blast furnace gas. Other small sources are the ladle de-kishing operation, pig casting machine cooling, slag quenching and miscellaneous other small sources including condensate. The non-process cooling water used to cool the blast furnace generates a small wastewater stream from the cooling tower blowdown.

The cleaning of blast furnace gas is usually a wet process both to cool and clean the gas for use in heating the blast furnace stoves, coke oven heating and steam generation. Modern practice is to use a high water recycle rate for gas cleaning. In a few cases the final stage of gas cleaning is by electrostatic precipitator, which reduces the volume of water circulated for gas cleaning.

Suspended solids in the wastewater are the dust particles carried by the blast furnace gas out of the blast furnace and collected in the gas cleaning water. Phenolic pollutants are attributable to the coke used in the iron-making process. Ammonia and cyanides are usually reaction products formed in the blast furnace. When coal injection is practised, there are no significant changes in the wastewater.

The wastewater stream from the ladle de-kishing station is small because of the high recycle rate and some loss due to evaporation as the hot kish and small amounts of molten slag are quenched. Suspended solids are the main pollutant in this stream.

The pig casting machine cooling water is an intermittent source since only a small amount of the hot metal is cast into pigs. Not all blast furnaces have a pig casting machine. Pollution comes from direct cooling of the hot pig iron. High recycle rates are used, and with the evaporation loss the wastewater stream is small. The major pollutant is suspended solids with some oil and grease from the operating equipment. The slag quenching wastewater stream for pit quenching is small since the majority of the quench water is evaporated. The wastewater pollutants include suspended solids and sulphur compounds. If the slag is granulated, the wastewater stream is generated by the air pollution control scrubber but, again, the stream is small due to high recycle and contains suspended solids.

Concentrations of pollutants contained in blast furnace wastewater stream were determined by EPA through a sampling program. The average concentrations are shown in Table 3.1.4.1. Typical water flows were in the range of 5,000 to 12,000 L/tonne of iron produced.

TABLE 3.1.4.1 RAW WASTEWATER POLLUTANT CONCENTRATIONS FROM BLAST FURNACE OPERATIONS

Pollutant	mg/L
pH (Units)	6.4 - 12.1
Ammonia (N)	72.4
Fluoride	32.5
Phenols (4AAP)	1.82
Suspended Solids	1032
Hexachlorobenzene	0.022
2,4-Dichlorophenol	0.034
Fluoranthene	2.31
Phenol	0.76
Benzo(a)pyrene	2.08
Chrysene	0.07
Pyrene	2.17
Arsenic	0.15
Cadmium	0.20
Chromium	0.28
Copper	0.39
Cyanide (total)	14.6
Lead	47.9
Nickel	0.66
Selenium	0.025
Zinc	223

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume II Iron Making Subcategory, EPA 440/1-82/024, May 1982

3.1.4.2 Air Emissions

The major sources of emissions from the blast furnace are casting, slag cooling, stove heating and hot metal desulphurization. Other sources include the handling and charging of raw materials, hot metal transportation, ladle cleaning and handling of material collected by dry-type air pollution control systems. Indirect emissions are produced by the combustion of the blast furnace gas.

Raw Material Handling:

The handling and charging of the blast furnace raw materials - coke, flux and iron-bearing material - generate small quantities of particulate matter. Since enclosed conveyors are usually used and the distances involved are not large, the quantity of particulate emitted is relatively small.

Blast Furnace Operation:

Because the blast furnace is a totally enclosed process, there are no emissions during normal furnace operation. However, if the blast furnace is not running smoothly, the burden may slip (material in blast furnace drops suddenly creating an abrupt increase in gas pressure), causing the furnace to discharge emissions of particulate, gases and partly-burnt carbon through the bleeder valves at the top of the furnace.

Iron Tapping:

Tapping of the blast furnace is one of the major sources of emissions. As the molten iron flows out of the furnace, along the runners and into the hot metal ladle, emissions of iron fumes and fine iron oxides occur. Since the molten iron is cooling at the same time, some of the carbon comes out of solution and is emitted as graphite particles.

Slag:

Emissions of fine particulate are also generated from the slag after it is separated from the iron and flows along the slag runner to the slag pit. Small amounts of the sulphur in the slag may be oxidized to SO_2 during the cast and emitted. The sulphur remaining in the slag is present as CaS. When water contacts the hot slag (as in the quenching and cooling processes), H_2S emissions are produced.

Measurements of H_2S concentrations inside a cover mounted over a section of the slag pit being quenched peaked at 250 ppm H_2S by volume. The slow cooling of the slag before quenching or the granulation or pelletization of the molten slag reduces the generation of total reduced sulphur compounds (TRS). Particulate emissions are generated when the quenched slag is dug out of the slag pit and during crushing and handling operations.

Hot Metal Desulphurization:

Hot metal pretreatment is being used increasingly to optimize the overall steel-making process or when special steel compositions are required. Hot metal pretreatment is carried out adjacent to the blast furnace or adjacent to or in the steel-making shop. Hot metal desulphurization is most widely used but recently de-siliconization and de-phosphorization have also attracted attention, especially in Japan.

There are ten or more types of hot metal desulphurization in commercial use depending on the flux and addition method. They can be classified into four - the soda ash, calcium carbide, lime and magnesium methods. When soda ash (Na_2CO_3), NaOH and others are used as desulphurization agents the slag generated contains Na_2S, SiO_2, $Na_2O.SiO_2$, etc. When calcium carbide (CaC_2) is used the slag contains CaS, CaO and some active CaC_2. With lime treatment limestone is added to improve stirring by decomposition gas. The slag generated contains $2CaO.SiO_2$. The magnesium injection takes advantage of the metal's strong affinity for sulphur. The metal has a low boiling point and easily vaporizes. High sulphur removal efficiency is achieved by impregnating coke briquettes with magnesium or using a magnesium lime mixture. The slag generated contains MgO, CaO and SiO_2.

The slag generated depends on the amount of sulphur to be removed, the injection rate, skimming and the quantity of slag charged into the BOF.

The injection of the desulphurization agent into the hot metal in the ladle creates turbulence in the hot metal and the generation of emissions. While most of the desulphurization material is either reacted with the sulphur in the iron or trapped in the slag, some may be emitted together with iron oxide and graphite particles.

Hot Metal Transport:

The gradual cooling of the hot metal and the turbulence caused by the motion of the ladle generate small quantities of fine iron oxide fumes and graphite platelets (kish) emissions from the hot metal ladle during transport to the melt shop. Similar emissions are generated from the residue of slag, kish and the heel of hot metal remaining in the ladle on its return to the blast furnace. In most plants this material is dumped from the ladle (ladle cleaning) into a water pool in the de-kishing station, which also generates emissions of kish and other particulate material.

Pig Casting:

In those plants that intermittently cast some of the molten iron into pigs at the casting machine, minor quantities of particulate material, including kish are generated.

Blast Furnace Gas:

Since blast furnace gas is recovered for use as fuel in the plant, particulate matter is removed at the blast furnace. The blast furnace gas cleaning system is a two- or three-stage process that is considered a part of the blast furnace operation. Coarse particles, larger than 0.8 mm, are removed in the dust-catcher. This material is periodically removed from the dust-catcher through a pug mill where water is added. The material is then recycled.

In modern plants, with the blast furnace operating at higher top gas pressures, the gas is cooled and cleaned in a high-efficiency venturi scrubber. The particulate content of the cleaned gas less than 12 and may be as low as 5 mg/Nm^3, although furnaces operating at lower top gas pressures have higher residual particulate concentrations. *

Stove Heating:

The stoves are usually heated by a blend of blast furnace gas and coke oven gas. Since both of these fuel gases are cleaned before use, the particulate emissions are those remaining in the fuel gas after cleaning. SO_x emissions result from the combustion of sulphur compounds remaining in the coke oven gas. The blast furnace gas contains only trace quantities of H_2S and SO_2 due to the efficiency of the iron oxide and flux in removing sulphurous gases before the blast furnace gas exits from the furnace. Because of the combustion characteristics of these fuel gases, the formation of NO_x is inherently lower than for other fuels.

Emissions of VOCs (1.4 kg/tonne of iron) and manganese (0.9 g/tonne iron) have been reported. **

The uncontrolled emission factors for the blast furnace area are contained in Table 3.1.4.2.

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* Reference: Handbook of Air Pollution Technology, John Wiley & Sons, 1984

** Reference: Emission Factors for Iron and Steel Sources -- Criteria and Toxic Pollutants, EPA-600/2-90-024, June 1990.

TABLE 3.1.4.2 UNCONTROLLED EMISSION FACTORS FOR BLAST FURNACE OPERATION (1)

Source	(kg/tonne hot metal)(2)	(kg/tonne hot metal)(3)
Blast furnace slip		39.5
Cast house (SO_2) (CO)	0.35 0.018 0.026	0.65
Slag pouring	0.14	
Slag crushing and screening	0.12	
Desulphurization	0.5	0.55

Note: (1) Particulate unless otherwise noted.

Sources: (2) Handbook of Air Pollution Technology, John Wiley & Sons, 1984

(3) Compilation of Air Pollutant Emission Factors Volume 1: Stationary Point and Area Sources, Fourth Edition, Supplement B, AP-42, September 1988

Emissions of dioxins have been measured at one blast furnace in Sweden. The concentration in the flue gas was 0.001 ng/Nm^3 or approximately 0.02 ug/tonne iron. *

3.1.4.3 Solid Waste

The major solid wastes are the slag, coarse dust collected by the dust catcher and the dust and sludge collected by pollution control equipment. Total collected flue dust is about 43.5 kg per tonne of hot metal produced. Typical particle size distribution of blast furnace dust and sludges is shown in Table 3.1.4.3 and typical flue dust compositions (US) are shown in Table 3.1.4.4.

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* Source: Wradhe, Hans; National Environmental Protection Board, Sweden; 1990-04-24, Personal communication.

TABLE 3.1.4.3 TYPICAL PARTICLE SIZE DISTRIBUTION OF BLAST FURNACE DUST AND SLUDGE FOR U.S.A. (%)

(microns)	500	250	125	62	44	34	24	16	9	4.5
BF dust	2	18	35	32	13					
BF sludge				24	17	6	7	16	9	21

Source: Management (The) of Steel Industry By-products and Wastes, International Iron and Steel Institute, Committee on Environmental Affairs, Brussels, October 1987

TABLE 3.1.4.4 TYPICAL CHEMICAL COMPOSITION OF BLAST FURNACE DUST AND SLUDGE (US)

Component	Quantity (%)	
	Dust	Sludge
Fe (total)	17 - 54	22 - 43
C	4 - 54	18 - 41
SiO_2	5.2 - 13.4	6.2 - 9.3
CaO	1.8 - 11	2.8 - 8.2
Al_2O_3	0.8 - 7.6	0.3 - 4. 7
Pb	0.01 - 0.2	0.04 - 1.0
Zn	0.01 - 0.2	0.04 - 2.6

Source: Management (The) of Steel Industry By-products and Wastes, International Iron and Steel Institute, Committee on Environmental Affairs, Brussels, October 1987

Slag generation rates for various countries are shown in Table 3.1.4.5.

TABLE 3.1.4.5 BLAST FURNACE SLAG GENERATION RATES 1984/5

Country	Range (kg/tonne hot metal)
Austria	355 - 464
Belgium	305 - 331
France	310 - 820*
Italy	289 - 333
Japan	300 - 350
Sweden	160 - 300
United Kingdom	276 - 311
United States/Canada	170 - 340
FR Germany	241 - 324

* High phosphorus iron

Source: Management (The) of Steel Industry By-products and Wastes, International Iron and Steel Institute, Committee on Environmental Affairs, Brussels, October 1987

The principal constituents of blast furnace slag are silica, alumina, lime and magnesia. Minor constituents include oxides of iron, manganese and titanium, and sulphur compounds. It should be noted, however, that the major oxides do not occur in free form in the slag. They are combined to form various silicate and alumino-silicate minerals such as melilite, merwinite, wollastonite, etc. The chemical composition of blast furnace slag is shown in Table 3.1.4.6.

TABLE 3.1.4.6 CHEMICAL COMPOSITION OF BLAST FURNACE SLAG

Component	Quantity (%)	
	Average (1)	Range (2)
SiO_2	36	27 - 38
Al_2O_3	10	7 - 15
CaO	39	32 - 43
MgO	12	3 - 18
FeO	0.5	0.2 - 1.6
MnO	0.4	0.2 - 1.1
TiO_2	**	0.4 - 2.1
S (principally as CaS)	1.4	0.8 - 1.9

Notes:
(1) 'Average' based primarily on US data
(2) 'Range' reflects worldwide data
** Insufficient data to determine average value

Source: Management (The) of Steel Industry By-products and Wastes, International Iron and Steel Institute, Committee on Environmental Affairs, Brussels, October 1987

The range of compositions of desulphurization slag is shown in Table 3.1.4.7. The composition varies according to the amount and method of flux addition and the method of slag skimming. Quantities range from 2.25 to over 15 kg/tonne of hot metal.

TABLE 3.1.4.7 RANGE OF CHEMICAL COMPOSITIONS OF DESULPHURIZATION SLAG

Component	Quantity (%)
SiO_2	3 - 40
Al_2O_3	7 - 20
CaO	5 - 70
MgO	1 - 30
Fe (total)	5 - 60
MnO	0.4 - 15
S	1 - 5
C	1 - 11.5
Na_2O	25 - 32

Source: Management (The) of Steel Industry By-products and Wastes, International Iron and Steel Institute, Committee on Environmental Affairs, Brussels, October 1987

Another source of solid waste is the refractories used in the blast furnace area. The iron and slag runner refractory - high alumina, carbon and fireclay - has to be replaced on a routine basis. High alumina and silicon carbide refractory materials are used for the tap hole and are replaced for each tap. Fireclay, high alumina, silicon carbide and carbon refractories are used for the blast furnace lining.

The blast furnace lining will last from three to ten years before it has to be replaced. Silica and high alumina refractories are used for the blast furnace stoves and have to be replaced periodically. Usually the refractory in one or more stoves is replaced when the furnace is relined. Fireclay and high alumina refractories are used in the ladle car linings and are replaced after 100,000 to 600,000 tonnes of hot metal have been transported. The length of time varies according to plant practice, interim repair methods and frequency and the amount of desulphurization carried out.

3.2 Steel Making

3.2.1 Material Handling

3.2.1.1 Wastewater

Usually no wastewater streams are generated in the steel-making raw materials handling. All air pollution controls are normally of the dry type.

3.2.1.2 Air Emissions

Scrap handling does not normally create any significant air emissions although minor emissions may occur during torch cutting of the larger pieces of scrap.

The hot metal transfer creates fugitive-type air emissions. These are discussed in Section 3.2.2.

The fluxes for steel making are normally delivered by enclosed trucks and unloaded pneumatically thus minimizing fugitive emissions. The uncontrolled emission factor for unloading is about 0.014 kg per tonne of steel. Similarly the handling of the fluxes is mostly carried out in enclosed systems and the major particulate emissions are at transfer points. The uncontrolled particulate emission factor is estimated at 0.04 kg per tonne of steel.

3.2.1.3 Solid Waste

The only solid waste are from the air pollution control systems. Total quantity is estimated at 0.05 kg per tonne of steel. Since this is primarily fluxes, the material is normally recycled or used in other parts of the plant.

3.2.2 Basic Oxygen Steel Making

3.2.2.1 Wastewater

The four main water systems used in BOF steel-making operations are:

1. Oxygen lance cooling
2. Furnace trunnion ring and nose cone cooling
3. Hood cooling
4. Fume collection scrubbing and gas cooling

The first three systems are for indirect-type cooling and do not generate wastewater except for the small cooling tower blowdown which can be used as part of the make-up water for the gas cooling and scrubbing system.

The process wastewater is generated by the fourth system. The use of closed hoods and suppressed combustion systems for the BOF has led to the increased adoption of wet scrubbing systems for air pollution control although European steel producers make wider use of electrostatic precipitators. In these systems the off-gas from the converter is cooled in a water spray-type quencher. The coarse materials in the gas stream drop out in the gas quencher and are removed as a slurry for treatment. The gas is then cleaned in a high-efficiency venturi scrubber and the solid particulate settles out in a sump and is withdrawn for further treatment. The majority of the wastewater from the venturi scrubber is recycled to the gas quencher and scrubber in modern plants.

Typical wastewater characteristics are shown in Table 3.2.2.1 for wet-suppressed combustion and Table 3.2.2.2 for wet-open combustion.

TABLE 3.2.2.1 TYPICAL RAW WASTEWATER CHARACTERISTICS FOR BASIC OXYGEN FURNACE - WET-OPEN COMBUSTION

Characteristic		Concentration (mg/L)	Mass (kg/tonne steel)
Flow, L/tonne	1,740		
pH (units)	3.4 - 8.8		
Fluoride		24.3	0.042
Suspended Solids		4594	8.00
Cadmium		0.064	0.00011
Chromium		0.369	0.00064
Copper		1.4	0.0024
Lead		3.93	0.0068
Mercury		0.0023	0.000004
Zinc		0.211	0.00037

Source: Development Document for Effluent Limitations Guidelines, New Source Performance Standards and Pretreatment Standards for the Iron and Steel Manufacturing Point Source Category. Volume III EPA 440/1-82/024, May 1982

TABLE 3.2.2.2 TYPICAL RAW WASTEWATER CHARACTERISTICS FOR BASIC OXYGEN FURNACE - WET-SUPPRESSED COMBUSTION

Characteristic		Concentration (mg/L)	Mass (kg/tonne steel)
Flow, L/tonne	4,070		
pH (units)	6.6 - 12.3		
Fluoride		NA	NA
Suspended Solids		720	2.93
Cadmium		0.064	0.00026
Chromium		0.614	0.0025
Copper		0.14	0.00057
Lead		0.24	0.00098
Zinc		3.4	0.014

Source: Development Document for Effluent Limitations Guidelines, New Source Performance Standards and Pretreatment Standards for the Iron and Steel Manufacturing Point Source Category. Volume III EPA 440/1-82/024, May 1982

3.2.2.2 Air Emissions

The molten iron from the blast furnace is transported to the steelmaking operation in the hot metal ladle (torpedo car). When the hot metal ladle car arrives at the melt shop, the ladle is rotated to pour the hot metal into either a transfer ladle or the charging ladle. In the case of the transfer ladle, it, in turn, is emptied into the charging ladle. During the hot metal transfer from one ladle to the other, particulate emissions are generated, consisting primarily of a mixture of fine iron oxide fume and graphite platelets (also known as kish).

The operation of the basic oxygen steel-making convertor accounts for about 90 percent of the total emissions from the steel-making activities. The emissions from the oxygen converter vessel occur over several periods of time. Since this is a batch-type process lasting 45 to 60 minutes, the cycle is repeated up to 25 or more times each day. The first step in the cycle is the charging of scrap. Emissions are generated by the scrap falling into the hot converter. Any small particles of extraneous material associated with the scrap together with fumes generated when the scrap hits the hot furnace are flushed out of the converter with the hot plume. Any oil associated with the scrap are burnt or partially burnt, adding soot and partially burnt hydrocarbons to the plume.

Similarly, when the hot metal is charged into the converter, emissions of fine iron oxides and kish will be generated. During the oxygen-blowing portion of the process, the pollutant emission rate is extremely high. The emissions include iron-bearing particulate matter, volatile metal fumes and oxides and carbon monoxide. The volume of the gas flow and the pollutant mass leaving the converter varies according to the type of oxygen steel-making process and the hood design. The largest volume and mass are generated by top-blown converters with open hoods, while the smallest volume and mass are generated by combination-blown converters with tight hoods and suppressed combustion.

Since very little nitrogen is used in the steel-making process, very little NO_x is generated in the blowing process. Some NO_x is generated by the combustion process in the hood and at the flare stack if the waste gas is flared. (The systems using the suppressed combustion process in the hood generate sufficiently high concentrations of carbon monoxide that the off-gas must be flared if it is not recovered for its fuel value.)

During turndown high emissions can also occur, depending on the type of scrap used. The QBOP must be turned down on oxygen for some types of heats.

Particulate emissions also occur when the converter is tilted to obtain steel samples and temperature measurements and during the tapping and slag removal operations, but since no oxygen is being blown at these times, the emissions are smaller in comparison to those generated during the oxygen blowing period. The emissions are generally greater for the QBOP since some inert gas must be blown at all times.

Another small source of particulate emissions is from the handling of the flux materials. This is discussed in Section 3.2.1.2. Other miscellaneous sources of air emissions include the preheating of ladles, handling of slag and fugitive dust. These sources are very small.

Uncontrolled emission factors for the oxygen steel-making process are shown in Table 3.2.2.3.

The particulates contain small concentrations of copper, lead zinc, nickel and other trace metals that may be contained in the scrap charge. There is limited data available on the emissions of these pollutants and this is summarized in Table 3.3.2.4.

Emissions of dioxins are reported, in Sweden, to be 0.002 ng/Nm^3 or 0.04 ug/tonne steel. *

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* Source: Wradhe, Hans: National Environmental Protection Board, Sweden, 1990-04-24, Personal communication.

TABLE 3.2.2.3 UNCONTROLLED PARTICULATE EMISSION FACTORS FOR OXYGEN STEEL-MAKING PROCESS

Source	Units	Emission Factor
Basic oxygen furnace (BOF) melting and refining	kg/tonne steel	14.25 69 (1)
BOF Charging	kg/tonne steel	0.125
QBOP Charging	kg/tonne steel	0.3
BOF Tapping	kg/tonne steel	0.08
QBOP Tapping	kg/tonne steel	0.46
Hot metal transfer	kg/tonne steel	0.095

Note: (1) Carbon monoxide

Source: Compilation of Air Pollutant Factors Volume I: Stationary Point and Area Sources, Fourth Edition, Supplement B, 9/88

TABLE 3.2.2.4 CRITERIA AND TOXIC POLLUTANT UNCONTROLLED EMISSIONS FROM THE BOF PROCESS

Pollutant	Emission Rate (g/tonne of steel)
NO_x	40
VOCs	0.5
Copper	5.3
Cadmium	0.02
Manganese	150
Nickel	0.9
Zinc	150

Source: Emission Factors for Iron and Steel Sources -- Criteria and Toxic Pollutants, EPA-600/2-90-024, June 1990.

3.2.2.3 Solid Waste

The major solid wastes are the slag generated from the steel-making process and the materials recovered from the pollution control systems.

About 140 kg of slag is generated per tonne of steel produced in the basic oxygen converter. This is about 93 percent of the total steel-making slag. Composition ranges of basic oxygen converter slags are contained in Table 3.2.2.5.

TABLE 3.2.2.5 COMPOSITION RANGES OF BASIC OXYGEN STEEL-MAKING SLAGS

Material	Weight (%)
CaO	40 - 46
MgO	2 - 8
SiO_2	10 - 15
Al_2O_3	1 - 2
FeO	18 - 30
MnO	5 - 7
TiO_2	0.5 - 1.5
S	0.05 - 0.1
P_2O_5	0.5 - 2

Source: Management (The) of Steel Industry By-products and Wastes, International Iron and Steel Institute, Committee on Environmental Affairs, Brussels, October 1987

Secondary steel-making slags include the slags from desulphurization, deoxidation, steel de-phosphorization, inclusion, modification and removal and tundish slag. These slags account for about 7 percent of the total steel-making slags. The specific output and chemical composition of these slags vary depending on the nature of the agents used and the output can vary between 5 and 15 kg/tonne of steel. Typical chemical composition of these slags are shown in Table 3.2.2.6.

TABLE 3.2.2.6 COMPOSITION RANGES OF BASIC OXYGEN STEELMAKING SECONDARY SLAGS

Material	Weight (%)
CaO	23 - 55
MgO	1.8 - 12
SiO_2	7 - 36
Al_2O_3	2 - 39
Fe (total)	0.4 - 45
MnO	0.1 - 6
S	0 - 0.7
P_2O_5	0 - 1

Source: Management (The) of Steel Industry By-products and Wastes, International Iron and Steel Institute, Committee on Environmental Affairs, Brussels, October 1987

About 19 kg of BOF dust and sludge are generated for each tonne of steel produced. A typical size analysis of the BOF sludge is shown in Table 3.2.2.7a and the chemical analysis is shown in Table 3.2.2.7b.

TABLE 3.2.2.7a TYPICAL SIZE ANALYSIS OF BOF SLUDGE

Size	Cumulative Weight %
35 Mesh	12
100 Mesh	43
325 Mesh	82
400 Mesh	83
5 Micron	95

TABLE 3.2.2.7b TYPICAL CHEMICAL ANALYSIS OF BOF SLUDGE

Material	Weight %
Fe	49
Zn	0.10
Pb	0.02
Na_2O	0.06
K_2O	0.02
S	0.08
C	0.50

Source: Harris, Morley M.,The Use of Steel Mill Waste Solids in Iron and Steelmaking, AIME Conference 'Disposal, Recycling and Recovery of Electric Furnace Exhaust Dust', 1987

The other major solid waste is the refractory material that is discarded from the basic oxygen vessel relining and ladle relining. Magnesite and dolomite are the principal refractories used for the basic oxygen vessel lining while fireclay and high alumina refractories are used for the ladle linings. Basic oxygen vessel lining life varies from 1,000 to 3,000 heats or more depending on the specific steel plant practices that are used. The refractory consumption ranges from 1.25 to 3.75 kg per tonne of steel although part of this refractory material is contained in the slag.

3.2.3 Electric Furnace Steel Making

3.2.3.1 Wastewater

Water is used for indirect cooling of electric furnace components. The only wastewater generation from this source is the cooling tower blowdown.

Since the air pollution control systems are mainly of the dry type (and no wet systems should be used), there are no other wastewater sources.

3.2.3.2 Air Emissions

The sources of emissions from the electric arc furnace operation depend on the particular configuration of the steel-making process. The major air emissions are from the operation of the electric furnace. Some minor emissions of particulate occur from the torch cutting of large pieces of scrap. Minor emissions of gaseous pollutants are generated from the heating of ladles.

The quantity and type of emissions from an electric furnace depend upon many factors, including furnace size, type and composition of the scrap, type of furnace, process melting rate, number of charging back charges, refining procedure and tapping duration and temperature. Furnace emissions are the highest during melt-down and refining operations but charging and tapping emissions can also be significant, especially if ladle additions are made during the tap and dirty scrap is charged.The increasing use of high power transformers and oxygen lancing to reduce the production cycle time also increases the emission rates during melt-down and refining.

Uncontrolled emission factors for electric furnaces are shown in Table 3.2.3.1.

TABLE 3.2.3.1 UNCONTROLLED EMISSION FACTORS FOR ELECTRIC FURNACES

	Mass emitted (kg\tonne steel)		
Pollutant	Melt and refine	Charge and tap	Total cycle
Particulate	7.5 - 20	0.8 - 1.0	8.3 - 21
Carbon monoxide			0.26 - 3.3
Nitrogen Oxides			0.05
Sulphur oxides			0.005
Fluorides			0.002- 0.35

Source: Electric Arc Furnaces and Argon-Oxygen Decarburization Vessels in Steel Industry: Background Information for Proposed Revisions to Standards, EPA 450/3-82-020a, July 1983

The particulate emissions may contain fluorides, lead, chromium, nickel, zinc and cadmium emissions depending on the trace element concentrations in the scrap and fluxes. There is limited data available on the emissions of these pollutants and this is summarized in Table 3.2.3.2.

Emissions of dioxins are reported, in Sweden, to be between 0.1 and 5 ng/Nm^3 or 0.2 to 10 ug/tonne steel. *

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* Source: Wradhe, Hans: National Environmental Protection Board, Sweden, 1990-04-24, Personal communication.

TABLE 3.2.3.2 **CRITERIA AND TOXIC POLLUTANT UNCONTROLLED EMISSIONS FROM ELECTRIC FURNACE STEEL MAKING**

Pollutant	Emission Rate (g/tonne of steel)
NO_x	50
VOCs	175
Copper	52
Cadmium	0.02
Manganese	260
Nickel	0.3
Zinc	350

Source: Emission Factors for Iron and Steel Sources -- Criteria and Toxic Pollutants, EPA-600/2-90-024, June 1990.

3.2.3.3 Solid Waste

The major amount of solid waste is the furnace slag and the material collected by the air pollution control systems. A minor amount is from broken refractory from ladle and furnace repairs.

About 150 kg of slag is generated for each tonne of steel produced. The typical composition of a basic electric furnace slag is shown in Table 3.2.3.3.

TABLE 3.2.3.3 TYPICAL BASIC ELECTRIC FURNACE SLAG COMPOSITION

Constituent	Percent by Weight
Lime, CaO	40.9
Silica, SiO_2	13.4
Iron Oxide, FeO	14.8
Alumina, Al_2O_3	3.5
Magnesia, MgO	8.2
Manganous Oxide, MnO	12.7
Phosphorus Pentoxide, P_2O_5	0.6
Sulphur, S	0.1

Source: The Making, Shaping and Treating of Steel, 10th Edition

Approximately 8.3 kg of electric furnace dust is generated per tonne of steel produced. The typical dust composition and size distribution are shown in Tables 3.2.3.4a and b.

TABLE 3.2.3.4a TYPICAL SIZE ANALYSIS OF ELECTRIC FURNACE DUST

Size	Cumulative Weight %
400 Mesh	10
5 Micron	40
< 5 Micron	50

TABLE 3.2.3.4b TYPICAL CHEMICAL ANALYSIS OF ELECTRIC FURNACE DUST

Material	Weight %
Fe	38
Zn	3.3
Pb	1.4
Na_2O	0.25
K_2O	0.20
S	0.25
C	1.0

Note: Does not add up to 100%; oxygen not included

Source: Harris, Morley M., The Use of Steel-Mill Waste Solids in Iron and Steelmaking, AIME Conference 'Disposal, Recycling and Recovery of Electric Furnace Exhaust Dust', 1989

3.2.4 Vacuum Degassing and Ladle Metallurgy

3.2.4.1 Wastewater

Vacuum Degassing:

The major source of wastewater from the vacuum degassing process is from the cooling of the steam jet ejector steam. The jet ejector steam contains pollutants carried out of the steel by the vacuum degassing operation. The wastewater is discharged to the sump through a barometric leg.

The balance of the water used in vacuum degassing is for indirect cooling. The only wastewater stream is the small blowdown from the cooling tower.

Ladle Metallurgy:

The only water used in the ladle metallurgy process is for indirect cooling. The only wastewater stream is the small blowdown from the cooling tower.

Typical wastewater characteristics for the vacuum degassing and ladle metallurgy processes are shown in Table 3.2.4.1.

3.2.4.2 Air Emissions

Air emissions from vacuum degassing are minimal since the only emissions are generated by the minor turbulence in the ladle during the transport of the ladle from location to location.

TABLE 3.2.4.1 TYPICAL RAW WASTEWATER CHARACTERISTICS FOR VACUUM DEGASSING AND LADLE METALLURGY

Characteristic		Concentration (mg/L)	Mass (kg/tonne steel)
Flow		2,060 L/tonne	
pH	(units)	6.3 - 7.4	
Suspended solids		100	0.206
Manganese		17.0	0.035
Chromium		0.0	0.0
Copper		0.29	0.00060
Lead		0.32	0.00066
Nickel		0.23	0.00047
Zinc		3.26	0.0067

Source: Development Document for Effluent Limitations Guidelines, New Source Performance Standards and Pretreatment Standards for the Iron and Steel Manufacturing Point Source Category. Volume III EPA 440/1-82/024, May 1982

Minor particulate emissions are generated in the ladle metallurgy process when additives are charged into the open ladle. If ladle reheating is practiced an electric furnace is used and the emissions are similar to those from electric furnace steel making but of lower volume and of shorter time duration. Minor emissions from the combustion of gas occur when ladle pre-heating is used.

3.2.4.3 Solid Waste

A minor amount - approximately 0.3 kg per tonne of steel - of sludge material is generated by the vacuum degassing process. Other solid wastes, also minor, are broken refractory from ladle and vessel repair, empty additive containers and slag if slag raking of the ladle is practised. This slag would report with the steel-making slag.

3.2.5 Teeming

3.2.5.1 Wastewater

Little water is used in the teeming operation. Limited amounts of wastewater are generated from clean-up operations or, when mould coating is used, from the preparation of the mould coating.

3.2.5.2 Air Emissions

Limited quantities of air emissions occur during the teeming operation from the mould coating if it is of the organic type, from the oxidation of a small amount of iron as it falls from the ladle into the mould, from the insulating material placed on the top of the ingot after teeming and on the removal of the hot top refractory material. The uncontrolled air emissions are estimated at 0.035 kg per tonne of steel teemed. If leaded steels are teemed (usually not produced in a large integrated steel plant) the uncontrolled emissions are 0.405 kg per tonne of leaded steel teemed. *

3.2.5.3 Solid Waste

Some iron scrap is produced from spillages and stringers. This iron scrap is recycled to the blast furnace. The refractory hot top material is discarded as solid waste. The quantity is approximately 2 - 5 kg per tonne of ingots cast and is suitable for landfill disposal.

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* Compilation of Air Pollutant Factors Volume I: Stationary Point and Area Sources, Fourth Edition, Supplement B, 9/88

3.2.6 Continuous Casting

3.2.6.1 Wastewater

The continuous casting process has the following three main water systems:

1. Copper mould non-contact cooling water
2. Machinery non-contact cooling water
3. Cast product spray contact cooling water

Of these systems only the cast product spray cooling water is contaminated, although there may be small blowdown streams from the non-contact cooling water towers. A fourth and smaller source of wastewater is the cut-off torch slag flushing water.

In the third system, the spray water washes away the scale that forms on the surface of the hot steel and also becomes contaminated with oils and greases released by the hydraulic and lubrication systems.

Typical wastewater characteristics are shown in Table 3.2.6.1.

3.2.6.2 Air Emissions

Fumes from the ladle and molten stream and from the cut-off torches provide the air emissions from the continuous casting operation. The uncontrolled particulate emission factor for continuous casting is 0.06 kg per tonne of steel. *

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* Handbook of Air Pollution Technology, John Wiley & Sons, 1984

TABLE 3.2.6.1 TYPICAL RAW WASTEWATER CHARACTERISTICS FOR THE CONTINUOUS CASTING PROCESS

Characteristic	Concentration (mg/L)	Mass (kg/tonne steel)
Flow, L/tonne	8,250	
pH (units)	6.6 - 9.2	
Suspended solids	57	0.34
Oil and grease	22	0.2
Chromium	0.62	0.0079
Copper	0.11	0.00096
Lead	0.079	0.0005
Selenium	0.077	0.0002
Zinc	0.68	0.0064

Source: Development Document for Effluent Limitations Guidelines, New Source Performance Standards and Pretreatment Standards for the Iron and Steel Manufacturing Point Source Category. Volume III EPA 440/1-82/024, May 1982

3.2.6.3 Solid Waste

Solid wastes are the slag from the cut-off torches and any material collected from the pollution control systems. The total solid waste generated from these sources is estimated at 0.35 kg per tonne of steel.

3.3 Hot Forming

3.3.1 Reheating

3.3.1.1 Wastewater

The only wastewater normally generated by reheating is the blowdown from cooling towers for furnace component cooling water and minor quantities from leaks and cleanup. This wastewater would normally discharge to the hot mill scale pit.

3.3.1.2 Air Emissions

Air emissions from the reheating furnaces, including soaking pits, are generated by the combustion of the heating fuel. The uncontrolled emission factors for soaking pits using 100 percent fuel oil with a sulphur content of 1.0 percent are 0.1 kg of particulate and 0.22 kg of SO_x per tonne of steel heated and for reheating furnaces 0.21 kg of particulate per tonne of steel heated. * Present day practice in both North America and Japan is to minimize the use of fuel oil and to use coke oven gas or natural gas for soaking pits and reheat furnaces,

3.3.1.2 Solid Waste

Some solid waste is generated from mill scale at the reheating furnaces. It is included in the hot rolling mill solid waste.

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* Handbook of Air Pollution Technology, John Wiley & Sons, 1984

3.3.2 Surface preparation

3.3.2.1 Wastewater

The automatic hot scarfing machines used to remove the surface layer and surface imperfections of the hot steel prior to rolling generate fumes, smoke and slag. The fumes and smoke are usually collected in wet-type air pollution control equipment, which generates a wastewater stream. The slag is directed to a slag pit or flume beneath the scarfing machine and is broken up by high pressure (10 atmospheres) water jet and directed to the slag pit or flume. Usually the scarfer wastewater is then directed to the mill scale pit, although in some plants the scarfer has its own scale pit. Since scarfing is an intermittent operation and not all hot steel is machine-scarfed, the wastewater flow is intermittent.

3.3.2.2 Air Emissions

Air emissions result from the generation of iron oxide fumes and other particulate by the hot scarfing process. Uncontrolled air emissions of particulate are 0.05 kg per tonne of steel scarfed. *

3.3.2.3 Solid Waste

The solid waste generated by hot scarfing consists of the slag formed by the scarfing action and the particulate recovered by the air pollution control system. In both cases the solid waste is usually flushed into the hot-rolling mill scale pit and is included in the hot-rolling mill solid waste.

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* Handbook of Air Pollution Technology, John Wiley & Sons, 1984

3.3.3 Hot Rolling

3.3.3.1 Wastewater

Hot-forming wastewaters are comprised of direct contact descaling and cooling waters. The most significant sources of wastewater generated by hot rolling are descaling of the hot metal, cooling of hot rolled product, flushing scale flumes under the mill roller tables and the hot scarfer operation and air pollution control. Scale is formed on the surface of the ingots, slabs, blooms, billets and tube rounds when they are reheated for rolling. Some of the scale breaks off at the furnace exit and during transport on the roller tables. This scale is flushed by water in the flumes under the roller tables to the scale pit.

The hot-forming operations (blooming or slabbing rolling mills, section rolling mills and flat rolling mills) generally have four principal contact water systems:

i) High pressure descaling spray water

ii) Work roll and roll table spray cooling water

iii) Hot shear spray cooling water

iv) Flume flushing

During the hot-rolling operation, mill scale (iron oxide scale) forms on the surface of the hot steel. The scale is removed by direct contact high pressure (70 - 140 atmospheres) sprays which release water before each roll pass of the product.

The table rolls in contact with the hot steel and the mill work rolls are direct contact water-cooled to prevent surface cracking and surface deformation of the steel rolls due to contact with the high temperature steel and the sudden temperature changes.

Similarly, direct contact water-cooling is used for the hot shear components that come in contact with the high temperature steel and the water is directed to the scale flushing flumes.

Approximately 4 percent of the water sprayed on the hot steel evaporates. The rest, along with the roll and equipment cooling water, is discharged beneath the roller tables and rolling mill to flumes (trenches) where the scale is flushed to the scale pit.

The hot strip and sheet mills have two additional sources of wastewater:

i) Product cooling, including runout tables
ii) Coiler cooler water

Large quantities of cooling water are applied to the hot strip after it leaves the final mill finishing stand to cool the strip. Approximately 8 percent of this cooling water evaporates. The balance is either recycled or treated with the other hot mill wastewaters. The mill scale from the finishing stands is much finer than the scale produced elsewhere in the hot mill.

Pipe and tube mills (hot working) generate contact wastewaters from two sources:

i) Roll cooling spray waters
ii) Pipe quenching or cooling

Some pipe mills also have ancillary contact or process waters from hydrostatic pipe testing or other miscellaneous uses.

The amount of water recycled varies according to plant practice and can be as high as 90 percent with untreated water being used for flume flushing and treated water being used for direct cooling applications.

Scale and oil and grease are the conventional pollutants contained in the hot-forming wastewaters. The scale particles range in size from sub-micron to several millimetres. The scale particles are 70-75 percent iron and consist of ferrous oxide (FeO) and ferric oxide (Fe_2O_3). With the increase in the proportion of steel processed by continuous casting, the amount of scale produced in hot forming is reduced. The oil and grease found in the hot mill wastewater are as a result of oil conditioning, oil spills, line ruptures and excessive dripping of lubricants.

In the development of effluent regulations for the hot-forming subcategory, EPA characterized the hot-forming wastewater. The results of this characterization are contained in Table 3.3.3.1.

Also, EPA developed a model flow rate and characterization of the raw wastewater for the hot-forming subcategory. The results of this model are contained in Table 3.3.3.2.

TABLE 3.3.3.1 SUMMARY OF PRIMARY SCALE PIT RAW WASTEWATER POLLUTANT CONCENTRATIONS FOR HOT FORMING

Parameter	Primary	Section	Hot Strip & Sheet	Plate	Pipe & Tube
Flow (L/tonne)	9,030	19,780	22,070	14,160	19,860
Total suspended solids	66	43	36	49	79
Oil and grease	40	20	5.2	22	4.8
pH (units)	2.5-8.9	5.1-8.7	6.3-8.4	6.3-8.9	6.8-8.7
Chromium	0.16	0.024	0.14	0.037	0.016
Copper	0.28	0.045	0.017	0.11	0.065
Lead	0.14	0.027	<0.01	0.11	0.03
Nickel	0.19	0.094	0.11	0.29	0.088
Zinc	0.22	0.028	0.014	0.035	0.007
Methylene chloride	0.024	0.033	<0.01	0.025	0.0
Bis-(2 ethyl hexyl) phthalate	0.061	0.21	0.14	0.31	0.0

Note: All values are in mg/L unless otherwise noted

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume IV Hot Forming Subcategory, EPA 440/1-82/024, May 1982

TABLE 3.3.3.2 RAW WASTEWATER CHARACTERISTICS HOT-FORMING SUBCATEGORY

Operations	Flow (L/tonne)	Suspended Solids (mg/L)	Oil and Grease (mg/L)	pH (units)
Primary without scarfer	9,000	2,200	85	6-9
Primary with scarfer	13,300	3,000	56	6-9
Section	19,900	990	38	6-9
Hot Strip & Sheet	25,000	790	30	6-9
Plate	13,300	1,500	56	6-9
Pipe & Tube	21,600	910	35	6-9

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume IV Hot Forming Subcategory, EPA 440/1-82/024, May 1982

3.3.3.2 Air Emissions

The air emissions from the hot-rolling process consist of fine iron oxide fume generated by the hot-rolling action and oil fumes from the contact of lubricating oils with the hot steel. In both cases the air emissions are very small and are not quantified.

3.3.3.3 Solid Waste

Solid wastes are generated in the hot-rolling process from the oxide scale that forms on the heated steel and the slag from the hot scarfing operation. In both cases the solid waste is flushed into the scale pit. The majority (coarse fraction) settles in the scale pit and is periodically removed for disposal. This usually contains a significant concentration of oil.

The balance exits the scale pit with the wastewater and is collected in the wastewater treatment plant for disposal. Total mill scale generation is 61.5 kg per tonne of steel produced. Typical size characteristics and chemical analyses of this solid waste are contained in Table 3.3.3.3.

TABLE 3.3.3.3 TYPICAL SIZE CHARACTERISTICS AND CHEMICAL ANALYSES OF HOT-ROLLING MILL SCALE

Size	Cumulative Weight %	Chemical Analysis	Weight %
4 Mesh	9	Fe	69
20 Mesh	19	Zn	0.01
35 Mesh	64	Na_2O	0.06
100 Mesh	77	K_2O	0.09
325 Mesh	92	S	0.06
400 Mesh	94	C	0.70
5 Micron	-		

Source: Harris, Morley M., The Use of Steel-Mill Waste Solids in Iron and Steelmaking; Conference on Disposal, Recycling and Recovery of Electric Furnace Exhaust Dust, AIME 1987

Steel scrap is also generated in the hot-rolling operation but all steel scrap is recycled within the plant.

3.3 Cold Forming

3.4.1 Cold Rolling

3.4.1.1 Wastewater

The major use of process water in cold-rolling mills is for cooling and lubricating the rolls and the material being rolled. This is accomplished with flooded lubrication systems where a water-oil emulsion is sprayed directly on the material and rolls. Each roll stand usually has separate sprays and, where recycle is used, a separate recycle system. Modern cold-rolling mills use recycle and recovery systems to minimize oil usage and pollutant discharges.

Considerable heat is generated in the cold-rolling process and is removed by non-contact cooling water systems for both the rolls and the lubrication system. The water-oil emulsion is continuously circulated, filtered to remove suspended solids and cooled by indirect coolers. The water-oil emulsion is periodically changed and the system is usually cleaned before fresh emulsion is used.

The majority of wastewater for cold rolling is from the rolling oil system blowdown, discarded rolling oils (unless sold to outside contractors for reclamation), leaks and spillage from the rolling oil system and the cleaning agent used to clean the system, usually tetrachloroethylene or similar cleaning solvents. A minor source of oily wastewater is the mist eliminators on the rolling mill exhaust systems.

Typical wastewater characteristics for cold-rolling mills that were developed by EPA in their effluent regulation development program are contained in Table 3.4.1.1.

TABLE 3.4.1.1 RAW WASTEWATER CHARACTERISTICS FOR COLD-ROLLING OPERATIONS

Parameter	Net Concentration (mg/L)
Flow (L/tonne)	75
pH (units)	2.3 - 7.9
Total suspended solids	1508
Oil and grease	19,194
Dissolved iron	5.1
Chromium (total)	2.9
Copper	8.4
Lead	2.8
Nickel	3.8
Zinc	4.4
1,1,1-Trichloroethane	0.017
1,1-Dichloroethane	0.023
Chloroform	0.073
Flouranthene	0.28
Methylene chloride	0.21
Naphthalene	0.10
4,6-Dini tro-o-cresol	0.13
Phenol	0.023
Bis (2-ethyl hexyl) phthalate	0.11
Benzo-a-anthracene	0.34
Chrysene	0.23
Acenaphthylene	0.29
Anthracene	2.0
Fluorene	0.54
Phenanthrene	2.7
Pyrene	0.43
Arsenic	0.26
Cadmium	0.084

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume VI Cold Forming Subcategory, EPA 440/1-82/024, May 1982

3.4.1.2 Air Emissions

Only minor air emissions are generated by the cold-rolling operation. The only significant emission is oily mist which is present in the mill exhaust system.

3.4.1.3 Solid Waste

The solid waste collected in the water treatment system is discussed in Section 4.6.

3.4.2 Acid Pickling

3.4.2.1 Wastewater

Wastewaters are discharged from three major sources in the acid pickling process: (1) spent pickle liquor from the tanks in which pickling is performed, (2) rinse waters from the product rinsing step(s) immediately following pickling, and (3) from the fume scrubber systems if wet scrubbers are used. A fourth source is the absorber vent scrubber which is uniquely associated with hydrochloric acid regeneration systems. Small amounts of wastewaters may also be discharged from wet looping pits associated with some lines and from spills and leakage from the process piping and pumping systems.

A. Spent Pickle Liquor

The most concentrated wastewater in acid pickling is spent pickle liquor, an acid solution whose strength has been depleted through continued pickling. For continuous pickling operations, a side stream is usually discharged to maintain a constant acid strength in the pickling operation. Because spent pickle liquor is highly contaminated and low in volume, contract hauling off-site has been a common disposal method. Plants that do not have contract hauling discharge the spent pickle liquor into treatment systems for disposal or regenerate the spent acid for reuse. Typical pollutant concentrations for spent pickle liquor are contained in Table 3.4.2.1.

TABLE 3.4.2.1 SPENT PICKLE LIQUOR - GROSS RAW SPENT CONCENTRATIONS

Parameters		Sulphuric Acid Pickling (mg/L)	Hydrochloric Acid Pickling (mg/L)
Flow	(L/tonne)	72	183
pH	(units)	<1.0-2.0	<1.0-5.0
Dissolved Iron		49,300	73,230
Oil and Grease		25	3.9
Suspended Solids		2,140	395
Methylene Chloride		0.024	0.89
bis-(2-ethylhexyl)Phthalate		0.31	0.43
Antimony		-	2.19
Cadmium		0.33	0.22
Chromium		168	16.1
Copper		3.43	15.9
Lead		1.07	388
Nickel		23.7	12.4
Zinc		50	17.6

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume Vol V Acid Pickling Subcategory, EPA 440/1-82/024, May 1982

B. Pickle Rinse Water

The major source of wastewater is the rinsing operation following the pickling step. Although the amount of water used and discharged varies according to the product being pickled, the number of rinsing steps and the type of rinsing operation, the rinse water generally constitutes the highest flow and contributes much of the process pollutant load. Rinse water flows can be minimized with cascade, counter current or high pressure/high temperature spray rinse systems.

In cascade rinse systems the rinse water is cascaded through a series of tanks with the fresh water make-up entering the final tank and the wastewater discharging from the first tank. Cascade systems typically reduce rinse water flow by up to 90 percent. Typical pollutant concentrations for pickle rinse water are contained in Table 3.4.2.2.

TABLE 3.4.2.2 **RAW WASTEWATER POLLUTANT CONCENTRATIONS FOR** PICKLING RINSE OPERATIONS

Parameters		Sulphuric Acid Pickling (mg/L)	Hydrochloric Acid Pickling (mg/L)
Flow	(L/tonne)	645	708
pH	(units)	<1.0-6.4	1.1-5.0
Dissolved Iron		3,820	1,658
Oil and Grease		20.3	7.9
Suspended Solids		96	24
Methylene Chloride		0.021	0.72
bis-(2-ethylhexyl)Phthalate		0.042	0.011
Antimony		-	0.19
Cadmium		0.028	-
Chromium		6.22	0.18
Copper		2.42	0.58
Lead		0.43	0.32
Nickel		2.35	0.52
Zinc		12.7	36.2

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume Vol V Acid Pickling Subcategory, EPA 440/1-82/024, May 1982

C. Fume Scrubber Water

Wet fume scrubbers are used to collect and scrub fumes emitted from the pickling tanks. The acid and other contaminants contained in the fumes are collected in the scrubber water. The concentrations and quantities of pollutants in the scrubber water vary considerably and depend on such factors as the amount of fumes generated in the process, the water usage in the scrubber and the degree of recycle. The typical concentration of pollutants in fume scrubber water is contained in Table 3.4.2.3.

D. Absorber Vent Scrubber Water

The regeneration of spent hydrochloric acid pickling solutions is another wastewater source. The absorber vent scrubbers are used to collect and scrub fumes generated by the acid regeneration process. The concentrations of pollutants discharged from these scrubbers vary depending on the amount of fumes generated in the process, the water usage of the scrubber and the degree of recycle. The typical concentration of pollutants in absorber vent scrubber discharge water is contained in Table 3.4.2.3.

3.4.2.2 Air Emissions

HCl fumes are emitted from the pickle tanks and from the acid regeneration plant vent. The estimated uncontrolled emissions of these fumes are 0.015 kg HCl per tonne of steel pickled.

TABLE 3.4.2.3 FUME SCRUBBER AND ABSORBER VENT SCRUBBER RAW WASTEWATER POLLUTANT CONCENTRATIONS

Parameters	Tank Fume Scrubber (mg/L)	Absorber Vent Scrubber (mg/L)
Flow (L/tonne)	110	524
pH (units)	<1.0 - 3.7	1.7 - 7.6
Dissolved Iron	191	970
Oil and Grease	1.9	0.8
Suspended Solids	3.3	79
Methylene Chloride	-	0.81
bis-(2-ethylhexyl)Phthalate	0.16	0.039
Antimony	0.20	0.21
Cadmium	<0.010	<0.010
Chromium	0.89	0.50
Copper	0.09	0.95
Lead	<0.010	<0.10
Nickel	1.18	0.70
Zinc	0.15	1.08

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume Vol V Acid Pickling Subcategory, EPA 440/1-82/024, May 1982

3.4.2.3 Solid Waste

The major solid waste is the iron oxide material recovered from the acid regeneration plant. Any steel scrap generated in this operation is recycled within the plant.

If the spent pickle liquor is not regenerated, it becomes a waste which must be disposed of. In some cases it is sold as a chemical for municipal sewage treatment.

3.4.3 Alkaline Cleaning

3.4.3.1 Wastewater

Alkaline wastewaters result from the cleaning of intermediate steel products prior to their entry into other finishing operations (eg. pickling prior to hot coating or electroplating). The most significant pollutants contributed by the process are suspended solids, oil and grease and relatively low levels of some toxic metals. These pollutants originate in the alkaline cleaning bath,in the rinsing operation that follows the cleaning bath and from the blowdown of the fume scrubber usually associated with the cleaning operation.

The typical level of pollutants found in alkaline cleaning baths is shown in Table 3.4.3.1.

TABLE 3.4.3.1 ALKALINE CLEANING OPERATIONS - POLLUTANT LEVEL IN BATH

Pollutant or Wastewater Characteristic	Typical values (mg/L)
Alkalinity	1,000
Iron (total)	100
Oil and grease	1,500
pH (units)	12 - 13
Total dissolved solids	25,000
Total suspended solids	1,000
Temperature (deg. C)	20 - 95

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume VI Alkaline Cleaning Subcategory, page 348, EPA 440/1-82/024, May 1982

Typical pollutant concentrations for wastewaters from alkaline cleaning operations are contained in Table 3.4.3.1.

TABLE 3.4.3.1 ALKALINE CLEANING OPERATIONS RAW WASTEWATER POLLUTANT CONCENTRATIONS

Pollutant		mg/L
Flow	1,580 L/tonne	
pH (units)	7.2 - 11.7	
Dissolved Iron		0.14
Oil and Grease		9.3
Suspended Solids		9.2
Bis(2-ethylhexyl)phthalate		0.17
Di-n-octyl phthalate		0.010
Dimethyl phthalate		0.040
Antimony		0.030
Lead		0.038
Zinc		0.073

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume VI Alkaline Cleaning Subcategory, EPA 440/1-82/024, May 1982

3.4.3.2 Air Emissions

No significant air emissions are generated by the alkaline cleaning process.

3.4.3.3 Solid Waste

The only significant solid waste generated by alkaline cleaning is the sludge from the wastewater treatment, which is discussed in Section 4.6.

3.4.4 Annealing

3.4.4.1 Wastewater

Water is used in the annealing operation for the indirect cooling of furnace components. The only wastewater, if any, is the blowdown from cooling towers.

3.4.4.2 Air Emissions

NO_x emissions from the combustion process are the only significant pollutant emissions from the annealing operation. Since a sulphur-free gaseous fuel is used for quality reasons, there are no SO_x emissions and a relatively low level of particulate emissions.

3.4.4.3 Solid Waste

The only significant solid waste is the discarded refractory material from the repair of the annealing furnaces.

3.4.5 Coating

Only hot coating has been included in this section. Cold coatings such as chromium and tin for tin plate for packaging are specialized products and would be considered on a case-by-case basis. Strip and sheet painting lines are usually not included in an integrated steel plant and would be considered with other painting operations.

3.4.5.1 Wastewater

The major wastewater flows originating from hot coating operations are:

1. Dilute rinse waters from rinses following chemical treatment or surface passivation steps and from final rinses after coating. These waters contain suspended and dissolved solids, chlorides, sulphates, silicates, oily matter and varying amounts of dissolved metals (iron, zinc, chromium, tin, aluminum, cadmium) depending on which coating metal and process is used.

2. Concentrated intermittent discharges (including fluxes), chemical treatment solutions and regenerant solutions from in-line ion exchange systems. These discharges contain higher concentrations of the pollutants noted above.

3. Fume scrubber wastewaters produced by the scrubbing of vapours and acid mists from the coating steps.

Wastewaters are also generated from the pickling operations, discussed in Section 3.4.2, and from the alkaline cleaning operations, discussed in Section 3.4.3, and thus are not considered in this Section.

A small wastewater stream comes from the cooling tower blowdown. during the coating process using no-contact cooling water.

In their regulation development program, EPA characterized the wastewaters from the hot coating (zinc, galvalume, aluminum, etc.) operations. Typical wastewater characteristics are shown in Table 3.4.5.1.

TABLE 3.4.5.1 RAW WASTEWATER CHARACTERISTICS HOT COATING SUBCATEGORY

Parameter		Pollutant Concentration (mg/L)
Flow	1,000 L/tonne of product	
Suspended Solids		215
Oil and Grease		110
Hexavelant Chromium		3.4
pH (units)		1.7 - 7.9
Bis-(2-ethyl hexyl) phthalate		0.231
Di-n-butyl phthalate		0.032
Chromium		5.4
Copper		1.3
Lead		12.5
Zinc		25.3

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume VI Hot Coating Subcategory, EPA 440/1-82/024, May 1982

3.4.5.2 Air Emissions

Air emissions are generated from two operations.

The first is when an annealing furnace is included as part of the hot coating line and emissions of NO_x are generated. Since the annealing furnaces do not operate at high temperatures, the level of NO_x emissions is relatively low. The fuel is sulphur free to avoid contamination of the steel and no SO_x is emitted. Particulate emissions are low since a gaseous fuel is used.

The second operation is the coating process, which generates fumes at relatively low emission levels. However, the emissions often include zinc and zinc oxide fumes.

3.4.5.3 Solid Waste

The only significant solid waste generated is the sludge from the fume scrubber wastewater treatment, which is discussed in Section 4.6.

3.5 Utilities

3.5.1 Water Preparation and Distribution

3.5.1.1 Wastewater

Water usage in a steel plant has been estimated to range from 5,400 to 162,000 L/tonne of steel produced. About two-thirds is used for indirect cooling. Depending on the source and quality of the raw water, some water treatment is usually required. The only wastewater stream is the contaminated water from the water treatment. Normally this is a small stream.

3.5.1.2 Air Emissions

No air emissions are generated from the water preparation and treatment operation.

3.5.1.3 Solid Waste

The only solid waste generated is the sludge from the water treatment, which is discussed in Section 4.6.

3.5.2 Steam Generation and Distribution

3.5.2.1 Wastewater

The majority of wastewater for steam generation is the blow-down from the feedwater treatment system, which will contains acidic compounds, suspended solids and other pollutants. The amount of blow-down is dependent on the steam consumption and the quality of the make-up water. A small amount of wastewater is generated from cleaning of boilers and floors and leaks from boiler house piping and equipment. This latter wastewater is usually contaminated with oil and grease as well as suspended solids. In addition, boiler blowdown contains anti-corrosion agents, often chromium compounds and high concentrations of heavy metals from evaporation of makeup water.

3.5.2.2 Air Emissions

The air emissions depend on the fuel used to generate steam. In a typical integrated steel plant the central steam generation units are designed for multi-fuel operation and are fired with a mixture of coke oven gas and blast furnace gas, supplemented as required with fuel oil. Estimated particulate emission factors for central steam generation units are:

Particulate	0.015 kg/10^9 J for blast furnace gas; *
	0.0052 kg/10^9 J for coke oven gas; *

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* Source: Compilation of Air Pollution Emission Factors Volume 1: Stationary Point and Area Sources, Fourth Edition, Supplement B, AP-42, September 1988

Estimated emission factors for NO_x are:

For oil	0.34 kg/MIL BTU	(Source: EPA-450/1-78-001)
For coke oven gas	0.051 kg/MIL BTU	(Source: US Steel)
For blast furnace gas	0.026 kg/MIL BTU	(Source: Babcock & Wilcox)

Based on the above emission factors, the NO_x process weight emission factors for a typical steel plant steam generation operation are:

For oil firing:	1.05 kg/tonne steel
For coke oven gas firing:	0.16 kg/tonne steel
For blast furnace gas firing:	0.081 kg/tonne steel

The SO_x emission factor is determined by the sulphur content of the fuel used. If 100 percent blast furnace gas is used, the emission factor is zero; if desulphurized coke oven gas is used, the emission factor is 0.002 (or less) kg SO_x per tonne of steel.

3.5.2.3 Solid Waste

The major source of solid waste is the boiler feedwater treatment system blowdown sludge. This is discussed in Section 4.6.

3.5.3 Fuel Storage and Distribution

3.5.3.1 Wastewater

The only wastewater from the fuel storage and distribution operation is the process run-off from the oil storage area. Since an integrated steel plant uses the fuels generated in-plant, large quantities of fuel oil are not used or stored in the steel plant and the quantity of process run-off wastewater is relatively small.

3.5.3.2 Air Emissions

The only air emissions from the fuel storage and distribution system operation are minor emissions of hydrocarbon vapour from fuel oil storage tank vents and coke oven gas drip legs.

3.5.3.3 Solid Waste

No solid waste is generated by this operation.

3.5.4 Process Gases Production, Storage and Distribution

3.5.4.1 Wastewater

The water used in this operation is for indirect process cooling for air compressors and, if located on site, for the production of oxygen and nitrogen. The only wastewater stream is the blowdown from the cooling towers.

3.5.4.2 Air Emissions

No air pollutants are emitted from this operation.

3.5.4.3 Solid Waste

No solid waste is generated in this operation.

3.6 Non-Process Fugitive Emissions

The following excludes the sources of non-process fugitive emissions discussed in Sections 3.1 and 3.2. The major sources of non-process fugitive emissions are the wind action on un-covered storage areas, roads and parking lots within the plant, vehicular traffic on plant roads and losses of material from open or semi-open trucks.

The major pollutant is particulate material. The emission factors for these non-process fugitive emissions are site-specific since the calculations are based on the areas involved, wind speed and direction, amount and speed of vehicular traffic, the extent to which unpaved roads are used and the extent to which open areas are protected by vegetation. The detailed background and emission factor information are contained in the following documents:

1. Compilation of Air Pollutant Factors Volume I: Stationary Point and Area Sources, Fourth Edition, Supplement B, 9/88

2. User's Guide Emission Control Technologies and Emission Factors for Unpaved Road Fugitive Emissions, EPA/625/5-87/022, September 1987

3. Control of Open Fugitive Dust Sources, EPA 450/3-88-008, September 1988.

4.0 POLLUTION CONTROL TECHNOLOGY
AND
RESULTING POLLUTANT DISCHARGE

4.1 Iron Making

4.1.1 Raw Material Handling and Storage

4.1.1.1 Process Run-off Wastewater

The best control technology for process run-off wastewater is to provide an impervious base for each storage pile with a catchment drainage channel to collect the precipitation water and dust suppression liquid and a sedimentation sump to collect solids for recycling or disposal. The effluent is recycled to the dust suppression and car-washing operations with any surplus being directed to the blowdown treatment plant for treatment. This technology prevents contamination of the ground water and soil and prevents contaminated water from discharging into a waterway.

The wastewater from the railcar-washing operation is discharged to the blowdown final treatment plant after removal of solids in a sedimentation sump.

4.1.1.2 Air Emissions

The best control technology for air emissions is to minimize the movement of the materials, to design the storage piles to minimize wind erosion of material and to use dust suppression techniques (fresh water or water collected and recycled) on the storage piles that are susceptible to dusting. The material handling techniques for the materials that are prone to dusting include using operational methods that minimize dust formation at the work faces, avoiding material handling operations during periods of high winds and minimizing dust generation on roadways by the use of paved roadways that are periodically cleaned and the use of dust suppression materials on the roadways during dry weather.

The railcar unloading operations are carried out in enclosed buildings and the particulate emissions are controlled by fabric filters.

The railcar thawing and frozen coal grizzly operations, where required, are carried out in enclosed buildings and the particulate emissions from these operations, including crushing, are controlled by fabric filters. SO_x emissions are eliminated by the use of sulphur-free fuels. Some NO_x emissions are generated by the combustion of fuels for heating and railcar thawing unless electric heating is used.

Particulate air emissions during the empty railcar return travel are prevented by washing the empty cars prior to their leaving the plant.

All materials-handling conveyors are enclosed with fabric filters installed at all transfer points to control particulate emissions.

The controlled emission rates for the raw material handling and storage are shown in Table 4.1.1.1.

4.1.1.3 Solid Wastes

Solid waste is generated from the collection of the process run-off wastewater in the sedimentation sumps at the storage piles and from the air pollution control equipment. The majority of this material is recycled and the balance is disposed to landfill sites.

TABLE 4.1.1.1 CONTROLLED EMISSION RATES FOR RAW MATERIALS HANDLING AND STORAGE

Process or operation	Basis for Emission Measurement	Control Technology	Controlled Emission Rate
Iron ore handling and storage	kg particulate per tonne hot metal	Pile design, fabric filter on conveyors	0.06
Pellet handling and storage	kg particulate per tonne hot metal	Pile design, fabric filter on conveyors	0.005e
Coal handling and storage	kg particulate per tonne coal used	Pile design, dust suppress., fabric filter on conveyors	0.015

NOTES: e Estimated

Source: Handbook of Air Pollution Technology, John Wiley & Sons 1984

4.1.2 Sintering

4.1.2.1 Wastewater

The generation of wastewater must be minimized by the application of water recycling to the greatest extent possible, the use of dry-type air pollution control technology wherever feasible and the application of process and pollution control technology that reduces or eliminates wastewater streams.

Where wet scrubbing is practised, the EPA model process removes suspended solids from the process wastewaters by gravity sedimentation in a thickener. A polymeric flocculant is added to the thickener influent to optimize the removal of suspended solids. The thickener underflow is de-watered in a vacuum filter and the filtrate returned to the thickener inlet. More than 90 percent of the thickener overflow is returned to the sintering operation. The pH of the treatment system blowdown, which is typically alkaline, is adjusted to the neutral pH with acid. Oils and greases are removed by surface skimming in the thickener and also by entrainment with the solids which settle in the thickener.

EPA developed a model treatment process for the sinter plant wastewater. The discharge characteristics are shown in Table 4.1.2.1.

A small blowdown of wastewater may also be generated from the indirect water cooling system. When the sinter plant exhaust gas is desulphurized and/or de-nitrified, an additional wastewater stream that requires treatment is generated.

TABLE 4.1.2.1 SINTER PLANT WASTEWATER DISCHARGE CHARACTERISTICS

Characteristic	Value
Flow	500 L/tonne of sinter
Oil and grease	10 mg/L or 5.0 g/tonne
Total suspended solids	50 mg/L or 25 g/tonne
pH (units)	6 - 9

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume II Sintering Subcategory, EPA 440/1-82/024, May 1982, Table IX-2, P. 279

4.1.2.2 Air Emissions

The most common air pollution control technology used for sinter plants is the electrostatic precipitator. However, electrostatic precipitator collection efficiencies decrease when the basicity of the sinter strand feed is high due to the high particle resistivity. Optimum collection efficiency is usually attained by conditioning the gas stream with a small addition of SO_3. Some sinter plants in the United States use fabric filters or venturi scrubbers as a secondary control device. In sinter plants where there are high sinter fines recirculation and large quantities of in-plant iron-bearing dust sintered, it may be necessary to reduce the throughput of fines to prevent an overload on the air pollution control system.

Fabric filter technology has been used on some installations where the volume of oily mill scale is minimized to prevent excessive hydrocarbon emissions. In some cases, due to high feed basicity or high oil content of recycled mill scale, it may be necessary to use a wet scrubber type of air pollution control.

Fabric filter technology is commonly used for the control of air emissions from the crushing and screening operations. Fugitive type emissions are usually controlled by tight hooding at all dust-generating locations with dust collected by fabric filter technology if the air stream is not directed to the main air pollution control system.

The emissions of carbon monoxide from the sintering process may be as high as one percent but are not normally controlled. Some fluoride emissions will be present if the ore contains fluorides. Control of fluorides is usually carried out by selecting ores with low or no fluoride content or, when this is not possible, by the use of a wet scrubber on the windbox (controlled emissions of 0.001 mg/Nm^3 reported by Geneva Steel).

LAER Technologies:

In those sinter plants with high sulphur contents in the solid fuel and/or in the iron ore, desulphurization of the flue gas is carried out to reduce the SO_2 emissions.

The NKK-Shinkoshi process uses an ammonia-ammonium sulphate scrubbing medium. The Nippon Steel SSD (Sinter Slag Desulphurization) process uses a slurry of atomized BOF slag as the absorbing liquid. The lime-gypsum process can also be used for desulphurization. These processes will also reduce the particulate emissions but create wastewater streams and sludge solid wastes.

Controlled air emissions from the sinter plant are shown in Table 4.1.2.1.

TABLE 4.1.2.1 CONTROLLED AIR EMISSIONS FOR SINTER PLANT (1)

Process or Operation	Pollutant	Control Technology	Concentration (mg/Nm^3)	Process Weight (kg/tonne sinter)
Sinter windbox	Particulate	Fabric filter	25	0.10
	Particulate	ESP	50 (2)	0.19
	Fluoride as F	Material select.	0.10	0.027
	SO_x	Fuel	500 (2)	1.88
	NO_x	Burner design	400 (2)	1.5
Sinter discharge	Particulate	Fabric filter	20	0.05
Sinter building fugitives	Particulate	Fabric filter	20	0.0035
Sinter crush. and screening	Particulate	Fabric filter	20	0.005
For LAER:				
Sinter windbox	SO_x	Desulphurization	10 (3) 10 (4)	0.04 0.04
	NO_x	De-nitrification	70 (4)	0.28
	Particulate	Fabric filter	20	0.08e

NOTES: e Estimated

Sources: (1) Handbook of Air Pollution Technology, John Wiley & Sons, 1984

and Compilation of Air Pollutant Emission Factors Volume 1: Stationary Point and Area Sources, Fourth Edition, Supplement B, AP-42, September 1988

(2) New Developments in Sinter Technology; Buckel, M., Kersting, K., Kister, H. and Lungen, H.-B.; International Congress New Developments in Metallurgical Processing, May 1989

(3) Mukaida, Atsushi et al, Advances in Environmental Control Technology at Nippon Steel: Their Effects, Nippon Steel Technical Report no. 16, December 1980

(4) Outline of Environmental Countermeasures at the Keihin Works, NKK

De-nitrification of the sinter gas can be carried out using the NKK ammonia selective contact reduction process with an iron ore catalyst. The gas is reheated to 350°C and mixed with ammonia from the coke oven plant in a reaction vessel. The solid waste is spent catalyst which is returned to the supplier or recycled within the steel plant where possible.

4.1.2.2 Solid Wastes

The dust collected from the air pollution control equipment is usually recycled in the sinter plant. The sludge generated by the desulphurization and de-nitrification processes is treated prior to disposal. See Section 5.3.3.

4.1.3 Coke Production

4.1.3.1 Introduction

The generation and discharges of pollutants to the environment from the coke ovens can and should be reduced to a minimum by the use of advanced process and pollution control technology, careful plant design and well-planned, timely maintenance of all process and pollution control equipment.

4.1.3.2 Wastewater

The generation of wastewater should be minimized by the application of water recycling to the greatest extent possible, the use of dry-type air pollution control technology wherever feasible and the application of process and pollution control technologies that reduce or eliminate wastewater streams.

Coal Preparation:

All air pollution control equipment should be dry type to eliminate wastewater discharges.

Coal Charging:

Air pollution control for the coal-charging operation should be of the dry type to eliminate wastewater discharges.

Coke Pushing:

Air pollution control for the coal-charging operation should be dry type. However, if a wet-type air pollution control system is selected, the wastewater discharge should be used as make-up for the quench tower to eliminate wastewater discharges.

Quenching:

A dry-type coke quenching process is preferable for pollution control. However, if a wet-quenching process is used, clean water should be used as make-up and all quench wastewater should be recycled to eliminate wastewater discharges.

Flushing Liquor (Waste Ammonia Liquor):

The ammonia, both free and fixed, is removed in a semi-indirect ammonia still, such as the USS CYAM process described in Section 4.1.3.2. The use of caustic soda rather than lime in the fixed leg minimizes sludge formation and reduces downtime due to scaling problems. The wastewater stream from the still is clarified and then flow and concentration are equalized and heated, if necessary, before undergoing biological or activated sludge treatment.

A biological treatment process is the most common process used to treat coke oven wastewaters. It is an aerobic process with air being introduced by mechanical mixing of the water and air or by sparging with air from blowers. The biological treatment process used for the waste ammonia liquor is one where active bacteria in the form of solids are suspended in a containment vessel or aeration basin. The wastewater, often diluted with some cleaner water to reduce toxicity, is pH-adjusted in an equalization basin and enters the aeration basin where it contacts the suspended bacteria. These bacteria absorb the pollutants from the water and biochemically oxidize them ultimately to carbon dioxide and water, in the case of carbonaceous compounds, and to nitrate, in the case of ammonia and other nitrogenous compounds. When the denitrification process is added, additional reaction basins are required to create the controlled conditions for the process to produce nitrogen instead of nitrates. Generation of biological solids, which must be periodically removed from the system to maintain control, is a direct result of this process.

Wastewater is typically held in the aeration basin about two days to complete the biological process, while the biological solids are kept in the system about 50 days. The effluent from the biological treatment plant should then be transferred to the blowdown treatment plant (see Section 4.6 Blowdown Treatment Plant).

Barometric Condenser:

The use of a jet condenser instead of a barometric condenser minimizes blowdown. The blowdown should be directed to the waste ammonia liquor stream for treatment.

Primary Cooler Condensate:

The condensate from the primary cooler is usually added to the flushing liquor wastewater stream for treatment.

Light Oil Recovery Wastewater:

The use of an indirect-type system for light oil recovery eliminates process wastewater streams since no water comes into contact with the gas, the wash oil, the light oil or the final cooler. The only process wastewater stream would be a small quantity of condensate from the gas. There would be small wastewater streams from the cooling tower blowdown (directed to the final treatment plant), light oil storage tank vents and transfer point scrubbers (directed to the waste ammonia liquor stream for treatment) and pump, valve and piping leaks. All pumping stations, oil storage tanks and oil transfer points should be located on impervious, dyked pads with the pad effluent directed to the waste ammonia liquor stream for treatment in order to prevent contamination of ground water.

Coke Oven Gas - Ammonia and Hydrogen Sulphide Removal:

The wastewater stream from the ammonia removal system (see Section 4.1.3.2 for the process description) should be directed to the waste ammonia liquor stream for treatment.

The wastewater stream from the hydrogen sulphide removal process (see Section 4.1.2.2 for the process description) should be directed for treatment to the waste ammonia liquor stream or the blowdown treatment plant, depending on the process used and the pollutant concentration.

Coke Oven Plant Process Run-off Wastewater:

The coke oven plant process run-off wastewater is defined as that water resulting from precipitation in the area of the coke oven plant. This area includes that occupied by buildings and process equipment and a 20-metre zone surrounding them. This run-off water should be collected and directed to the blowdown treatment plant for treatment.

Coke Oven Plant, Including By-Product Plant, Process Wastewater After Coke Plant Treatment:

For their regulations for by-product coke ovens, EPA developed the model treatment process shown in Figure 4.1.3.1. The benzol plant wastewaters, naphthalene crystallizer blowdown and final cooler blowdown are mixed and treated with waste pickle liquor. This effluent is combined with the other by-product plant wastewaters and is treated with lime in an ammonia still to remove both free and fixed ammonia. The ammonia recovered from the still is injected into the coke oven gas stream. The pH of the effluent is lowered by the addition of acid and treated in a two-stage biological reactor with sludge recycle. Wastewater storage facilities are included for system outage protection.

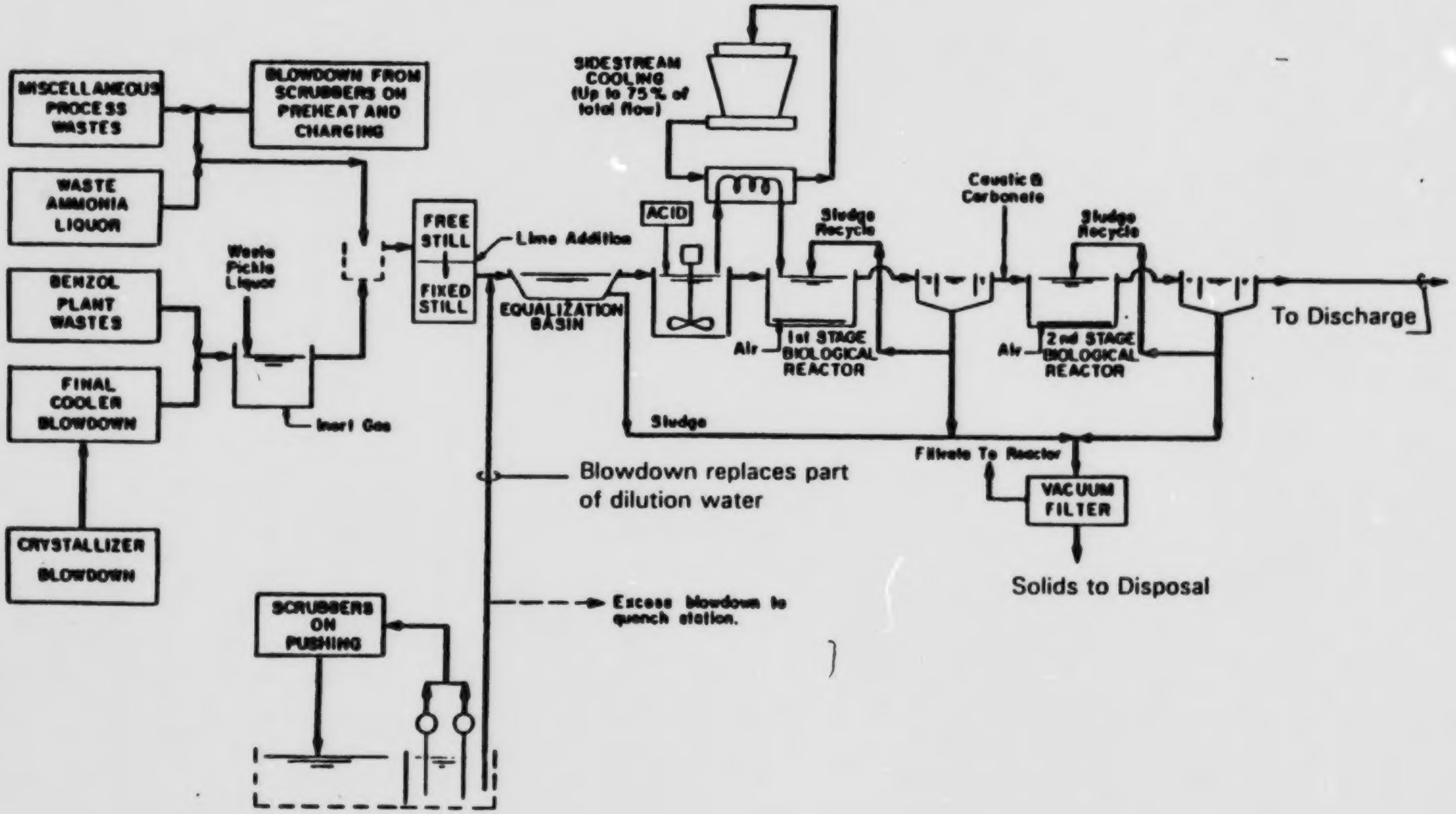
MISCELLANEOUS PROCESS WASTES
BLOWDOWN FROM SCRUBBERS ON PREHEAT AND CHARGING
WASTE AMMONIA LIQUOR
BENZOL PLANT WASTES
FINAL COOLER BLOWDOWN
CRYSTALLIZER BLOWDOWN
Waste Pickle Liquor
Inert Gas
FREE STILL
FIXED STILL
Lime Addition
EQUALIZATION BASIN
SIDESTREAM COOLING (Up to 75% of total flow)
ACID
Sludge Recycle
Air
1st STAGE BIOLOGICAL REACTOR
Caustic & Carbonate
Sludge Recycle
Air
2nd STAGE BIOLOGICAL REACTOR
To Discharge
Sludge
Filtrate To Reactor
VACUUM FILTER
Solids to Disposal
Blowdown replaces part of dilution water
Excess blowdown to quench station.
SCRUBBERS ON PUSHING

Figure: 4.1.3.1 EPA Model Treatment Process - By-Product Coke Making

Table 4.1.3.1 contains the achievable concentration and mass standards (1982) for a by-product coke plant utilizing the EPA by-product model treatment process.

TABLE 4.1.3.1 EPA COKE MAKING EFFLUENT STANDARDS

Parameter	Concentration (1) (mg/L)	Mass Standard (2) (g/tonne Coke)
Model Flow (3): 640 L/Tonne		
TSS	40	12.8
Oil & grease	5	3.19 (4)
Ammonia (N)	20	12.8
Cyanides (total)	5	3.19
Phenols (4AAP)	0.05	0.016
Benzene	0.03	0.019
Naphthalene	0.03	0.019
Benzo(a)pyrene	0.03	0.019
pH	6 to 9	

(1) Values shown are maximum daily concentrations.

(2) 30-day average. Daily maximum values are 1.82 times value for cyanide, 1.93 times for TSS, 2.00 times for phenols and 3.4 times for ammonia-N. Increased loadings not to exceed 39% of the standards are allowed for indirect ammonia recovery systems (ammonia is removed from the gas by water scrubbing).

(3) 390 L/tonne has been demonstrated.

(4) For oil and grease no monthly average is set. Value shown is daily maximum.

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume II Coke Making Subcategory, EPA 440/1-82/024, May 1982 (Table X-3 Alternative 3)

Table 4.1.3.2 contains the EPA New Source Performance Standards for coke plant effluents.

TABLE 4.1.3.2 EPA COKE MAKING EFFLUENT NEW SOURCE PERFORMANCE STANDARDS

Pollutant or Pollutant property	Maximum for any 1 day	Average of daily values for 30 consecutive days
	(g/tonne coke)	
TSS	172	89.4
Oil & grease	6.38	....
Ammonia (N)	54.3	16.0
Cyanides (total)	6.38	3.51
Phenols (4AAP)	0.0638	0.0319
Benzene	0.0319	....
Naphthalene	0.0319	....
Benzo(a)pyrene	0.0319	....
pH	6 to 9	

(1) Increased loadings, not to exceed 16 percent of the above standards, are allowed for by-product coke plants which have wet desulphurization systems but only to the extent such systems generate an increased effluent volume.

(2) Increased loading, not to exceed 39 percent of the above standards, are allowed for by-product coke plants which include indirect ammonia recovery systems but only to the extent such systems generate an increased effluent volume.

Source: Federal Register, 40 CFR Ch. 1 (7-1-89 Edition) #420.14 New source performance standards (NSPS) (a) By-product cokemaking -- iron and steel

4.1.3.3 New and Emerging Technology - Wastewater

The most important new or emerging technologies for the treatment of coke oven wastewater include:

- the addition of a blowdown treatment plant that has been demonstrated in a Canadian steel plant (This technology is discussed in Section 4.6.2.)

- the elimination of direct water cooling and scrubbing in the by-product coke oven gas processing plant

- the elimination of wastewater streams from the coke oven gas desulphurization process

- biological fluidized bed developments

  "A coupled biological fluidized bed system has been operated at pilot-scale size by Environment Canada's Wastewater Technology Centre in 1980-81. This system was shown to be capable of achieving complete nitrification and de-nitrification of undiluted coke plant wastewater at a total system hydraulic retention time (HRT) of approximately 16 hours. Total nitrogen removal efficiencies of more than 90 percent were maintained under steady and non-steady state conditions. Removal of conventional pollutants, including filtered organic carbon, phenolic compounds and thiocyanate, was consistently greater than 90 percent despite step changes in process loading and periodic reductions in the nitrification efficiency. The process also effected a high degree of trace organic contaminant control."(1)

- wastewater filtration

  The Wastewater Technology Centre of Environment Canada is also carrying out research on improved filtration technology for wastewater from iron and steel plants.

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(1) Biological Fluidized Bed Treatment of Coke Plant Wastewater and Blast Furnace Scrubber Blowdown, Environment Canada Report EPS 3/MM1, December 1984

Hoogovens in IJmuiden, The Netherlands, has developed filter technology to remove polycyclic aromatic hydrocarbons (PAH) from coke plant wastewater. PAH is a term used for a collection of polycyclic hydrocarbons of which two of the representatives are benzo(a)pyrene and benzperylene. Vacuum filtration with wood flour as a pre-coat material has reduced PAH concentrations to 20 ug/L in the coke plant wastewater.

- treatment of wastewater from wet oxidation sulphur removal processes

The wet oxidation sulphur removal processes for coke oven gas have created highly contaminated wastewater streams. Although the main process reactions are reversible, irreversible side reactions occur which form soluble salts such as thiocyanates, thiosulphates and sulphates. Unless these unwanted soluble salts are purged from the system, the sulphur conversion is reduced and the sulphur removal efficiency drops.

Dofasco Inc. has operated the Stretford process for a number of years and has developed a solution to this problem. Known as the Fixed Salts Recovery (FSR) process, it is a reductive incineration process which converts the soluble salts into reusable carbonates and sulphides. These are recycled back to the Stretford process, thus eliminating this wastewater stream.

The second wastewater stream associated with the Stretford process is the HCN scrubber blowdown. The Zimpro Wet Air Oxidation Process has been modified to oxidize the ammonia thiosalts and sulphur in the HCN blowdown to a solution of 35 percent ammonium sulphate and 1.5 to 2 percent sulphuric acid.

The ammonium sulphate is recovered in the ammonium sulphate plant and the sulphuric acid is used for the absorption of ammonia from the gas stream.

Similarly, Nippon Steel in Japan has developed the HIROHAX process which eliminates these wastewater streams from the TAKAHAX sulphur removal process.

- biological treatment of coke oven wastewaters using nitrification/de-nitrification

  This process achieves complete biodegradation of nitrogen-bearing wastewaters in a single reaction system, so steam-stripping pretreatment of the water can be eliminated. Equalization, aeration and clarification systems are similar to those used in conventional biological systems. A single activated sludge is used which simultaneously oxidizes nitrogen compounds to nitrate and reduces and liberates these nitrates as free nitrogen gas. The process has been operated at the pilot plant scale and a full-scale plant is currently under construction at Geneva Steel in the United States. *

4.1.3.2 Wastewater Control Technology - BACT and LAER:

The following advanced control technologies for the coke oven wastewater are considered to meet both BACT and LAER criteria:

- use dry-type air pollution control systems wherever possible, especially for charging and pushing emission control

- recycle all quench water if wet quenching is used

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* ENSR NITE/DENITE™ System, Bulletin No. 2-13, UEC, USX Engineers & Consultants, Inc.

- use ammonia still, free and fixed-leg, with caustic to remove ammonia from flushing liquor (unless the biological process has the capability to achieve complete biodegradation of the wastewaters without steam stripping)

- use biological treatment process discussed in Section 6.2.2 for flushing liquor treatment and discharge to the blowdown treatment plant

- use jet condenser to minimize generation of wastewater

- use indirect-type cooling for primary and final coolers to minimize generation of contaminated wastewater

- use indirect scrubbing for light oil removal to minimize generation of contaminated wastewater

- use local treatment and recycle to the greatest extent possible for chemical and contaminated blowdowns from sulphur recovery systems (In the case of the Stretford process, the Zimpro wet oxidation process and the Fixed Salts Recovery process or the HIROHAX process virtually eliminate the contaminated blowdowns and recycle the recovered chemicals)

- provide concrete drainage pads with dykes for light oil and wash oil pumping stations, storage tanks and truck loading and unloading stations with drainage to either the flushing liquor treatment system or the blowdown treatment plant discussed in Section 6.2.2

- discharge blowdowns from cooling towers to the blowdown treatment plant

- provide drainage to collect storm wastewater from the coke oven and by-products plant process area (including a 20-metre zone surrounding the buildings and process equipment) and discharge to the blowdown treatment plant.

4.1.3.3 Air Emissions

The control of air emissions in a coke oven plant requires a combination of air pollution control systems, close attention to good operating practices and a high level of maintenance.

Coal Preparation:

The use of high-efficiency fabric filter systems with effective hooding is the most suitable control technology for the control of particulate emissions for the coal crushing, blending and handling operations. Particulate emission levels as low as 10 mg/Nm^3 are achieved with this technology.

Coal Preheating:

Wet scrubbers are usually used to remove the particulates from the coal preheating waste gases.

Coal Charging:

A number of control technologies are used for coal charging. Although scrubbers mounted on the larry cars have been used, the high maintenance costs and low reliability have mitigated against their use. The best available technology is the stage (sequential) charging techniques. The stage charging as practised in North America involves charging coal into the oven from only one larry car hopper at a time.

The larry car is located above the opened charging holes and the drop sleeves under the coal hoppers are lowered to seal the hoppers to the oven. A slightly negative pressure is maintained in the oven to be charged by applying steam or flushing liquor aspiration in the goosenecks of the off-take. It is preferable to have a double collector main to have better aspiration and consequently lower emissions.

The coal is then charged into the oven, in some plants one hopper at a time in sequence, in others hoppers one and four. Once these hoppers are empty their slide gates are closed, the drop sleeves are raised and the charging lids are replaced. The coal in a third hopper is then charged. Immediately after the hopper is emptied, the slide gate is closed, the drop sleeve is lifted and the charging lid is replaced. There is still space above the coal in the oven for the gas passage. The last hopper is then charged into the oven blocking the gas passage. The leveller bar is used to level the coal in the oven, reopening the gas passage and allowing the last coal to enter the oven. The hopper slide gate is closed, the drop sleeve is raised and the charging lid is replaced. The leveller bar is retracted, the chuck door is closed, the aspiration is stopped and the oven is put on the main to start the coking cycle. Any coal spillage from the charging operation must be immediately cleaned up to reduce fugitive emissions.

Coking Cycle:

The emission control technology for the coking cycle is largely a combination of good operating and maintenance practices and new developments in coke oven design. New developments include:

- Door designs that are more flexible and follow the changing contour of the door jamb (These include the Saturn door used for some coke ovens in the US and Canada, the Krupp-Koppers door used in Europe and the IKIO door used in many countries.)

- Diligent maintenance of doors, off-take systems, lids and other coke oven components to avoid deterioration which leads to leaks, or, as an option, the use of silicon door sealant

- Effective luting program (manual application of refractory sealant to charging lids, chuck doors, off-takes and other areas of leakage)

- Use of door and jamb cleaning mechanisms that effectively remove hydrocarbon build-up without damaging the sealing surfaces

- Use of ceramic welding techniques to repair cracks and refractory deterioration to reduce the incidence of leakage into the flues and the atmosphere

Coke Pushing:

The most common technology used to control coke pushing emissions is a fixed hood mounted on the door machine car. The hood has moveable extensions to seal against the coke oven on either side and above the oven being pushed and will cover the active portion of the quench car. After the door is removed, the hood extensions are moved in to seal the oven and the hood is connected to a fixed duct leading to the air pollution control unit. Dry-type fabric filters are widely used and wet venturi scrubbers are used in some plants. If a wet-type scrubber is used, the water effluent is recycled with the blowdown being used as make-up for the quench tower.

The effectiveness of the emission control system is dependant partly on the design of the system but mostly on effective maintenance to ensure that there is maximum hood collection efficiency and maximum reliability of the overall system.

Operating practice is also important to ensure that green coke is not pushed. A poorly coked push will create a greater volume of emissions, often more than the system can handle, resulting in direct emissions to the atmosphere. In this situation, the concentration of organic compounds is also drastically increased. Inadequate coking may be due to too short a coking cycle, inadequate or faulty temperature control, uneven coking profile across the oven because of poor door sealing (which results in a cold end or flue leakage) or other causes that can be prevented by an effective maintenance program and good operating practice.

The emissions from the quench car while it is travelling to the quench tower are not normally collected when this control technology is used.

An alternate emission control technology is to enclose the coke side of the battery, including the quench car track, with a shed structure and evacuating the emissions from the shed to a fabric filter dust collection system. Wet-type scrubbers, either electrostatic or venturi, are sometimes used. The evacuation system is designed so that, while the complete shed is being continuously exhausted, the volume exhausted above the oven being pushed is increased. It is critical that the shed design collect all emissions and that the working conditions under the shed be satisfactory from the industrial hygiene viewpoint. The reliability of the system is also crucial to avoid deterioration of working conditions and discharge of uncontrolled emissions. The advantages of the shed system are that the emissions from the quench car when it is travelling to the quench station are controlled and there is more complete capture of fugitive type emissions from the coke side doors.

The capital cost is usually greater than for other pollution control systems. A number of sheds are presently being built at steel plants in the United States.

Another alternate system is the Minister-Stein design which is widely used in Europe and in several plants in North America.

Wet Coke-Quenching:

In wet coke-quenching the coke is transported in the quench car to the quench tower at one end of the coke oven battery. The coke is rapidly quenched by high-volume water sprays. A portion of the water is vaporized and exits the top of the quench tower while the balance is collected in the sump and is recycled.

The coarser particulate contained in the steam plume is captured by a series of wetted baffles in the top of the quench tower and flushed into the sump. The baffle design is critical in obtaining a higher efficiency of the particulate collection. The wet quenching operation is the largest source of particulate in the coke oven plant.

Dry Coke-Quenching:

The dry coke-quenching process has been used for coke ovens in Europe and Japan where high energy costs have improved the economics of dry-coke quenching, thus reducing coke pushing and quenching emissions. In the conventional dry-quenching process, the coke is pushed into an enclosed container and is transported to the dry coke-quenching facility. The hot coke is discharged from the transport container into the dry-quench facility and quenched with inert gas. Heat is recovered from the inert gas to produce steam, although it could also be used to preheat coal. The dry-quenching system has not been used in North America because of the high capital cost and lower energy costs.

A recent development is the KRESS dry-quenching process where the coke is pushed into a container that is transported by a mobile carrier. The coke, while remaining in the container, is quenched by the application of cooling water on the external shell of the container. After the coke has been quenched, it is removed from the container and processed in the conventional manner. The empty container is then returned to repeat the cycle. Energy to generate steam can be recovered from the process.

Dry-quenched coke generates more particulate emissions during crushing, screening, handling and transport to the blast furnace than wet-quenched coke. These emissions are controlled through the use of fabric filter technology.

Coke Crushing, Screening and Handling:

The quenched coke is dumped from the quench car at the coke wharf into a hopper which feeds a conveyor that transports the coke to the crushing and screening station. Dry-fabric, filter-type air pollution control systems are used to remove particulate generated at transfer points and at crushing and screening operations. As noted under dry quenching, dry-quenched coke is dustier than wet-quenched coke so also requires enclosed conveyor systems.

Coke Oven Gas - Ammonia Recovery:

Ammonia is removed from the coke oven gas to reduce pipeline corrosion and to facilitate sulphur removal. Ammonia can be recovered from the coke oven gas by scrubbing with water, followed by removal from the water by distillation and treatment with an alkali, after which the ammonia and steam are passed through the absorber. The operation to recover the ammonia is usually carried out in the ammonia still, discussed in Section 4.1.3.2. A more advanced system than the conventional ammonia still is the USS CYAM system.

Ammonia is also recovered as ammonium sulphate. The ammonia absorber process sprays dilute sulphuric acid into the gas as it rises through the absorber. The ammonia is converted into ammonium sulphate in solution and the solution is discharged to the crystallizer where the ammonium sulphate is crystallized, washed and packaged for sale. The crystallizer effluent is recycled to the absorber.

The USS PHOSAM process recovers the ammonia as anhydrous ammonia. Ammonia is scrubbed from the coke oven gas by counter-current contact with an ammonia-lean phosphate solution in a two-stage spray-type absorber resulting in 98 to 99 percent ammonia removal.

The absorbing solution is stable, non-volatile and highly selective for ammonia, rejecting acidic gases such as hydrogen sulphide and organic compounds that are present in the gas. The ammonia in the ammonia-rich solution from the absorber is stripped from the solution and recovered as high-purity anhydrous ammonia.

Coke Oven Gas - Sulphur Recovery:

Sulphur is present in the coke oven gas both as hydrogen sulphide and as organo-sulphur compounds in concentrations as high as 10 g/m^3 depending on the sulphur content of the coal.

Commercial coke oven gas desulphurization processes can be divided into two categories: those processes which use wet oxidation to produce sulphur and those which absorb and strip H_2S for subsequent conversion into sulphur or sulphuric acid.

1. Wet-Oxidation Processes - All wet-oxidation processes utilize a reduction-oxidation catalyst to facilitate the wet oxidation of hydrogen sulphide to elemental sulphur or sulphate.

All of these processes are characterized by a very efficient removal of sulphur but have the disadvantage of producing highly contaminated waste products which require elaborate wastewater treatment facilities. The new technology for treating the Stretford process wastewater streams is discussed in Section 4.1.3.3.

The Holmes-Stretford process removes all but a trace of the HCN, can reduce the H_2S to below 100 mg/Nm^3 and produces a saleable sulphur product.

The major wet-oxidation commercial processes, along with their reduction-oxidation catalysts, are listed in Table 4.1.3.3.

2. Absorption-Stripping Process - The absorption-stripping processes are characterized by generally lower H_2S removal, but, since air is not included in the regenerating system, contaminated waste products are minimized or eliminated. The processes can be operated to produce sulphuric acid or high-purity elemental sulphur. There are four principal absorption stripping processes in commercial use: the vacuum-carbonate process, the Sulfiban process, the Carl Still or Diamex process and the DESULF process.

   The vacuum-carbonate process removes hydrogen sulphide and other impurities such as hydrogen cyanide from the gas by counter-current scrubbing with a sodium carbonate solution. The hydrogen sulphide is stripped from the scrubbing solution and converted to elemental sulphur in a Claus plant or to sulphuric acid. The single-stage process reduces the H_2S content to about 1,150 mg/Nm^3 and the double-stage process reduces it to about 230 mg/Nm^3.

TABLE 4.1.3.3 Major Wet-Oxidation Desulphurization Processes and their Catalysts

Process	Catalyst
Takahax Process	Naphthaquinone-sulphonic acid
Holmes-Stretford Process	Anthraquinone-disulphonic acid and sodium ammonium vanadate
Fumaks Process	Picric acid
Thylox and Giammarco Vetrocoke	Sodium thioarsenate

Source: The Making, Shaping and Treating of Steel, 10th Edition, Association of Iron and Steel Engineers

The Sulfiban process utilizes monoethanalamine as the absorbing solution in a counter-current scrubber. The H_2S and HCN are steam-stripped from the sulphur-rich scrubbing solution and the acid gases are sent to a cyanide reactor to convert the HCN to ammonia catalytically. The ammonia can be recovered in a PHOSAM plant and the hydrogen sulphide is converted to high-purity elemental sulphur. A small amount of insoluble compounds (mainly ferrocyanides) is formed and must be removed from the system. The H_2S content of the gas is reduced to below 230 mg/Nm^3.

Carl Still or Diamox Processes - Both the Carl Still and Diamox processes use aqueous ammonia as the absorbing medium in a counter-current scrubber. The absorbing solution from the bottom of the H_2S absorber is stripped in the deacidifier and the acid gases are sent to a small PHOSAM plant where the ammonia is stripped. The HCN is catalytically decomposed in an HCN reactor and high-purity elemental sulphur is produced from the H_2S.

When about 15 percent of the ammonia is recycled from the PHOSAM plant to the absorber, the H_2S content of the coke oven gas is reduced to about 260 mg/Nm^3.

DESULF Process - This process uses ammonia water in a three-stage counter-current scrubber and the H_2S is stripped from the absorbing solution for conversion to elemental sulphur. The H_2S content of the coke oven gas is reduced to about 200 mg/Nm^3.

The United States Department of Energy (DOE) is sponsoring and financially supporting a desulphurization demonstration project with Bethlehem Steel at their Sparrows Point Plant, Baltimore County, Maryland. The process is based on the Carl Still process with a modified Claus plant to produce elemental sulphur. The targeted performance objective is to reduce the sulphur content to 1,600 mg/Nm^3. (Note that this is 6 to 8 times higher than that achieved by most of the processes discussed above).

Coke Oven Combustion:

The gas combustion in the battery flues produces emissions through the under-fire or combustion stack. Coke oven gas, blast furnace gas or a combination of the two are used for under-firing the ovens. Most of the particulate contained in the gas is emitted as particulate, but since both gases are normally cleaned with a very small concentration of particulate remaining, the amount of particulate emissions from this source is small. Some particulate originates from the coking process if the oven refractory is damaged and materials from the coking process can leak into the combustion gases. This is minimal if the ovens are well maintained.

Particulate emissions can be reduced to below 35 mg/Nm^3 by following good coking practice and maintenance procedures and practise.

Sulphur dioxide emissions are generated from the residual sulphur compounds left in the coke oven gas. If the coke oven gas is desulphurized to a low level, the sulphur dioxide emission level will be under 20 mg/Nm^3.

NO_x emissions are relatively low for the combustion of coke oven gas and even lower for blast furnace gas due to the lower calorific value, combustion characteristics and flame temperature. The NO_x emissions can be reduced even more through the use of the air stage-heating system for coke ovens. In this system the rich fuel-gas mixture is present in only a part of the flues and the flame and combustion characteristics reduce the formation of NO_x.

Operating results for coke ovens using the air stage system show an improvement in thermal efficiency and NO_x emissions in the range of 283 to 387 mg/Nm^3 for coke oven gas firing and 187 to 350 mg/Nm^3 for blast furnace firing.

The controlled particulate emission levels are contained in Table 4.1.3.4.

Many coals contain small concentrations of mercury and arsenic. While a portion of the mercury and arsenic is captured by the air pollution control equipment, some will escape into the air from the various coke oven operations. The best control method is to select coal supplies with minimum mercury and arsenic concentrations. Estimated mercury emissions for a well-controlled coke oven plant are estimated to be less than 0.02 g/tonne of coke and arsenic emissions are estimated to be less than 0.02 g/tonne of coke.

TABLE 4.1.3.4 CONTROLLED PARTICULATE EMISSION LEVELS FOR BY-PRODUCT COKE OVENS (1)

Type of Operation	Control Technology	Concentration (mg/Nm^3) (2)	Process Weight (kg/tonne coke) (2)	Process Weight (kg/tonne coke) (3)
Coal crushing and handling	Fabric filter	10	0.002	0.058
Coal preheating	Wet scrubber	25e	0.0125	0.012
Wet coal charging	Stage charging		0.014	0.008
Door leaks	Maintenance		0.05	
Coke pushing	Hood, fabric filter		0.03	0.045
Wet quenching	Multiple baffles		0.71	0.27
Combustion stack	Maintenance	35	0.71	0.1
(SO_x)	Desulphurized coke oven gas	20	0.24	
(NO_x)	Burner design, operations	300 (4)	3.55	
Topside leaks			0.03	

(1) Particulate unless otherwise specified.

Source: (2) Handbook of Air Pollution Technology, John Wiley & Sons 1984

(3) Compilation of Air Pollutant Emission Factors Volume 1: Stationary Point and Area Sources, Fourth Edition, Supplement B, AP-42, September 1988

(4) Schwarz, U. and Brown, M.; Air stage heating saves energy and reduces emissions, STEEL TIMES, February 1989

Organic Compound Emissions From By-Product Plant:

Coke oven emissions, containing a number of toxic or hazardous organic compounds, have been declared to be hazardous air pollutants by EPA. Benzene is the most common of these organic compounds and is often considered as a surrogate for other toxic or hazardous organic compounds. The uncontrolled emissions of benzene are discussed in Section 3.1.3. Control technologies that reduce the emission of benzene also reduce the emissions of other organic compounds.

LAER emission control technologies for benzene are as follows:

Tar, Wash Oil and Light Oil Fixed Roof Storage Tanks - Inert gas blanketing minimizes the emissions of benzene and other hydrocarbons from storage tanks using a manifold system. A small wash oil scrubber can be used to remove hydrocarbons from the inert gas so that the inert gas can be recycled.

Truck Loading and Unloading Stations - Vapour-balancing systems minimize the emissions of benzene and other hydrocarbons from tar, wash oil and light oil during truck loading and unloading operations.

Final Cooler, Cooling Tower and Naphthalene Handling - The use of wash oil scrubbing and indirect water cooling for the final cooler eliminates benzene and other hydrocarbon emissions from these sources.

Fugitive Emissions From Equipment Components - Fugitive emissions from equipment components can be minimized by good inspection and preventive maintenance procedures.

The controlled benzene emission levels (LAER) are contained in Table 4.1.3.5.

TABLE 4.1.3.5 CONTROLLED BENZENE EMISSION LEVELS FOR BY-PRODUCT COKE OVENS (LAER)

Source	g/tonne coke
Final-cooler cooling tower	0
Tar-intercepting sump	1.9
Tar decanter	1.5
Light oil condenser and decanter vent	1.8
Tar de-watering	0.4
Light oil sump	0.24
Tar storage	0.24
Pump seals	0.15
Flushing liquor circulation tank	0.18
Excess ammonia liquor tank	0.18
Benzene storage	0.12
Valves	0
Wash oil decanter and circulation tank	0.18
Pressure relief devices	0
Exhausters	0
Sample connections and open ended lines	0
Total	7

Source: Benzene Emissions from Coke By-Product Recovery Plants - Background Information for Proposed Standards, EPA-450/3-83-016a, May 1984

Fugitive Emission Monitoring - Monitoring of fugitive benzene emissions resulting from valve, pump and other equipment leaks cannot quantify the emissions. A leak-monitoring procedure, such as outlined in the EPA requirement contained in "National Emission Standard for Equipment Leaks (Fugitive Emission Sources), Subpart V, #61.240, 40 CFR Ch. 1 (7-1-88 Edition) Federal Register", is required to achieve the controlled benzene emission levels.

4.1.3.4 Solid Waste

Most of the solid wastes generated by a by-product coke plant are either recycled within the plant or sold. Coke breeze is either recycled in the plant, with the coal being charged into the coke ovens as fuel for a sinter plant, or sold to electric furnace steel-making plants as a furnace reductant. Tar is usually sold as a raw material to a chemical company but can also be used within the plant as a fuel or injected into the blast furnace.

Other tar-type wastes can be charged into the coke ovens with the coal. Ammonium sulphate, anhydrous ammonia, light oil and elemental sulphur are all marketable materials and can be sold. Ammonia still sludge can be avoided by using caustic soda instead of lime. The particulate collected by the air pollution control equipment and the coke breeze recovered from the quench tower are all recycled within the plant. The de-watered sludge from the biological reactor is the only solid waste that requires disposal and it is often recycled by being added to the coal charged to the coke ovens.

4.1.4 Iron Production (Blast Furnace)

4.1.4.1 Wastewater

The generation of wastewater must be minimized by the use of water recycling to the greatest extent possible. The blowdown from the gas cleaning water circuit, cooling towers, de-kishing station, pig casting machine, slag quench scrubber and miscellaneous sources is normally treated in a thickener (or similar gravity sedimentation unit) to remove suspended solids and other pollutants that are entrained in the suspended solids. The removal of the suspended solids is enhanced by the use of polymer flocculants. The sludge is de-watered in vacuum filters with the filtrate returning to the treatment system.

EPA, in the development of their effluent regulations, determined that several well-controlled plants carried out further treatment and developed the model treatment process shown in Figure 4.1.4.1. The process technology used in their model process is described below. The most advanced treatment processes used recycle rates as high as 98 percent and treated the blowdown, 290 l\tonne, in an inclined plate separator (or equivalent). Lime is added to the blowdown to raise the pH to 10.5 or greater. The toxic metal precipitates and other suspended solids formed by lime addition are removed in the inclined plate separators. Two-stage alkaline oxidation is used, with chlorine being added to the first reactor to convert the cyanides to cyanates and to oxidize ammonia-N and phenolic compounds. As the wastewaters leave the first reactor, acid is added to reduce the pH to 8.5. Additional chlorine is added in the second reactor to complete the oxidation of cyanides as well as of residual ammonia-N and phenolic compounds. The effluent is then de-chlorinated with appropriate reducing agents prior to discharge.

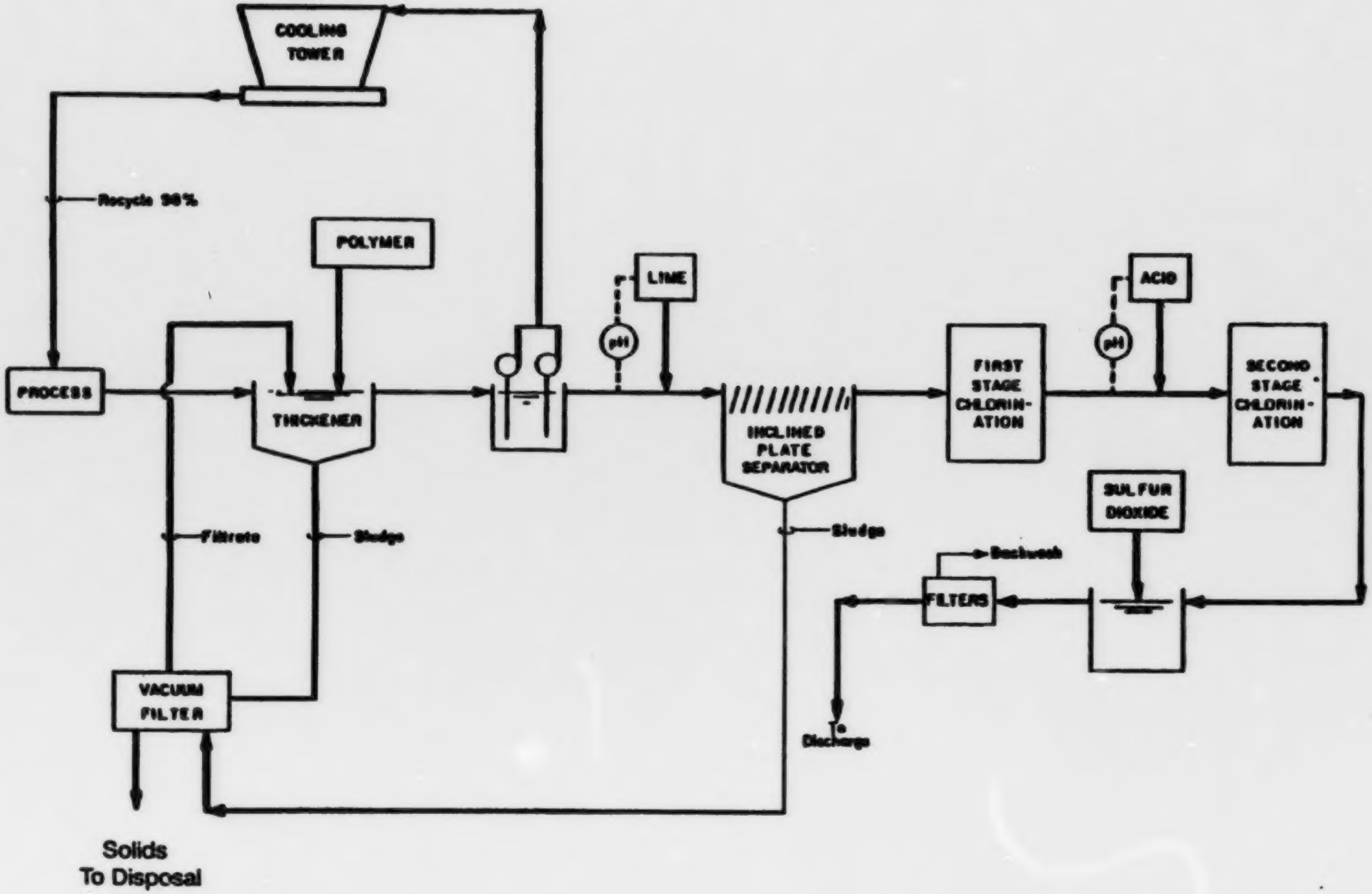

COOLING TOWER
Recycle 98%
POLYMER
PROCESS
THICKENER
LIME
pH
INCLINED PLATE SEPARATOR
FIRST STAGE CHLORIN-ATION
ACID
pH
SECOND STAGE CHLORIN-ATION
SULFUR DIOXIDE
Backwash
FILTERS
To Discharge
Filtrate
Sludge
Sludge
VACUUM FILTER
Solids To Disposal

Figure: 4.1.4.1. EPA Model Treatment Process - Iron Making

The EPA effluent pollutant concentrations and limitations, based on the above model treatment process, are shown in Table 4.1.4.1.

TABLE 4.1.4.1 EPA IRON-MAKING EFFLUENT STANDARDS (NSPS)

Parameter	Concentration (1) (mg/L)	Mass Standard (2) (g/tonne hot metal)
Model Flow:	292 L/tonne	
Total suspended solids	40	11.6
Ammonia (N)	30	9.0
Phenols (4AAP)	0.2	0.060
Cyanide (total)	2	0.60
Residual chlorine	0.5	0.15
Lead	0.75	0.22
Zinc	0.9	0.26
pH, (Units)	6.0 to 9.0	

(1) Daily Maximum Concentrations

(2) Daily Maximum Standards

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume II Ironmaking Subcategory, EPA 440/1-82/024, May 1982

The revised 1989 EPA New Source Performance Standards are shown in Table 4.1.4.2.

TABLE 4.1.4.2 EPA NEW SOURCE PERFORMANCE STANDARDS FOR BLAST FURNACES, 1989 (g/tonne hot metal)

Pollutant or pollutant property	Maximum for any 1 day	Average of daily values for 30 consecutive days
Total suspended solids	11.7	4.38
Oil and grease	2.92	....
Ammonia (N)	8.76	2.92
Cyanide (total)	0.584	0.292
Phenols (4AAP)	0.0584	0.0292
TRC (1)	0.146	....
Lead	0.263	0.0876
Zinc	0.394	0.131
pH (units)	6.0 to 9.0	

Note: (1) The standards for TRC shall be applicable only when chlorination of ironmaking wastewaters is practiced.

Source: Federal Register, 40 CFR Ch. 1 (7-1-89 Edition) #420.34 New source performance standards (NSPS). (a) Iron blast furnace. SUBPART C

4.1.4.2 Air Emissions:

Raw Material Handling:

Enclosed conveyor systems with high-efficiency fabric filter systems installed at transfer points achieve the lowest emissions from this source.

Blast Furnace Operation:

The control of emissions from blast furnace slips is to avoid slips to the greatest extent possible by using good operating practices and high-quality raw materials. The use of computer controls, especially with newly-developed sensors, assists the operators to maintain a smooth-running furnace operation.

Iron Tapping:

The best control technology for tapping operations is a combination of shortening the length of the runners, complete hooding and evacuation of the tap hole and iron and slag runners and using high-efficiency fabric filter dust collection systems. The use of a tilting runner is one technique for shortening the length of the runners. The use of trough and runner materials with low coal tar and petroleum pitch contents also assists in minimizing emissions.

Slag:

Emissions from the slag in the cast house should be collected with the emissions from the iron tapping and handling. One control technology for the reduction of total reduced sulphur (TRS) and other emissions from the slag quenching and cooling is the use of a pelletizing or granulating technology in an enclosed space. The plume from the process should be ducted to a wet scrubber to minimize the particulate and TRS emissions.

Pelletizing or granulation technology also reduces the emissions from slag crushing, screening and handling since the product does not require primary crushing and is relatively dust-free.

An alternative is to air-cool the molten slag until it is below the temperature at which TRS are formed before water quenching. After quenching, the dust generated by the reclaiming of the slag can be minimized by the use of water for dust suppression. The further processing of the slag is normally carried out by an outside party as a separate operation and is discussed in Section 4.7.

Hot Metal Desulphurization:

High-efficiency wet scrubber, electrostatic precipitator or fabric filter control technology with effective hooding over the ladle car at the desulphurization station is the best technology for controlling emissions from the hot metal desulphurization. Since this is an intermittent process, the air pollution control system for the cast house control is often used for this application. If the hot metal desulphurization is carried out at the steel-making shop, the ladle transfer dust collection system is usually used.

Hot Metal Transport:

The optimum control method for this operation is to minimize the heat loss during transport, limit the amount of extraneous material in the ladle, use as small an opening as possible without increasing emissions from hot metal splashing onto the outside of the ladle and use a cover over the opening during transport.

Blast Furnace Gas:

Since blast furnace gas is an important in-plant fuel, a high-efficiency wet scrubber is used for particulate removal. The particulate content is reduced to below 10 mg/Nm^3, thereby minimizing particulate emissions from the combustion of the gas.

Stove Heating:

The stove-heating process minimizes the emission of particulate, SO_x and NO_x, because of the combustion characteristics of the coke oven gas and blast furnace gas used. Any coke oven gas that is used is desulphurized, so SO_x emissions are minimal.

The controlled emission factors for the blast furnace are shown in Table 4.1.4.3.

TABLE 4.1.4.3 CONTROLLED PARTICULATE EMISSION FACTORS FOR BLAST FURNACE OPERATION USING BAT

Source or operation	Control Technology	(kg/tonne hot metal) (1)	(kg/tonne hot metal) (2)
Cast house	Fabric filter	0.021	
Slag pouring	Fabric filter	0.007	
Slag crushing and screening	Fabric filter	0.013	
Hot metal desulphurization	Fabric filter		0.0045
Stove combustion (3) (4)	Maintenance	(5)	

Source: (1) Handbook of Air Pollution Technology, John Wiley & Sons 1984

(2) Compilation of Air Pollutant Emission Factors Volume 1: Stationary Point and Area Sources, Fourth Edition, Supplement B, AP-42, September 1988

(3) No emission factors were identified for the particulate and CO emissions.

(4) Emission factor for NO_x for blast furnace gas is 0.028 kg/gigajoules or approximately 0.040 kg/tonne of hot metal (source: Babcock & Wilcox)
SO_x emissions will be minimal due to the very low concentration of sulphur in the blast furnace gas.

(5) Particulate concentrations ranging from 4 to 30 mg/Nm^3 were measured at three blast furnaces in the United States (personal communication)

4.1.4.3 Solid Waste:

Flue Dust:

The flue dust, about 43.5 kg per tonne of hot metal produced, is added to the sinter plant feed in some plants that operate a sinter plant.

New processes that are being developed to agglomerate steel-plant waste solids for recycle within the steel plants are generally of three types:

1. low temperature bonding
2. hot briquetting
3. direct reduction

The pellets and briquettes produced are intended for use in the blast furnace and, therefore, must have sufficient strength not to decrepitate in the blast furnace stack.

The low-temperature bonding and the hot-briquetting processes do not provide for zinc removal and, therefore, their application would be limited to either low zinc reverts or to specific locations where the zinc content of reverts does not present a problem. The direct-reduction processes produce highly metallized, low-zinc, low-lead and low-alkali content pellets for use in the blast furnace.

The low-temperature bonding processes that have been demonstrated at the plant operating level include:

- Reclaform - Revert materials were blended with coal-tar pitch and briquetted in a roll-type briquetting press and oven cured. They were successfully used in a 20-day blast furnace trial in 1976 with no operating problems.

- MTU - Mill scale is ground to 90 percent minus 200 mesh and then combined with blast-furnace flue dust and steel-making dust. Lime and silica are added and the stream is mixed in water, aged for several hours, pelletized and dried and hardened in an autoclave. The pellets were successfully used in a two-week blast furnace trial in 1977 with no operating problems.

- Aglomet - This is a hot-briquetting process that heats the feed materials to about 1000 °C in a fluid bed and then forms the hot material into briquettes which have been used in a one-month blast furnace trial with no operating problems.

Direct-reduction processes have been demonstrated in Japan where there were seven plants built prior to 1980 (only one operating at the present time). All but one of the plants were grate-kiln processes. The direct-reduction processes are energy- and capital-intensive and have not been adopted in North America.

Slag:

The blast furnace slag is a saleable product as a construction aggregate, railroad ballast or, when pelletized or granulated, as an aggregate for low-weight concrete.

The calcium sulphide (CaS) contained in the slag can cause some leachate of sulphur upon exposure to the atmosphere. This problem can be avoided if the slag is aged (weathered) for a few months prior to use or oxidized by treatment with an oxidizing agent.

Slag from the desulphurization of hot metal is processed for metal recovery and, depending on the desulphurization process and reagent, recycled to the blast furnace as flux or used as landfill. The material recovered from ladle cleaning is processed to recover the iron and the balance is recycled to the sinter plant or blast furnace for its carbon content.

4.2 Steel Making

4.2.1 Material Handling

4.2.1.1 Wastewater

No wastewater streams are normally generated in this area since the air pollution control technology use is the dry type.

4.2.1.2 Air Emissions

High-efficiency fabric filters are the best technology for controlling air emissions from the flux handling system. The controlled emission factor is 20 mg/Nm^3 or 0.0006 kg per tonne of steel produced.

4.2.1.3 Solid Waste

The material collected by the air pollution control systems is normally recycled.

4.2.2 Basic Oxygen Steel Making

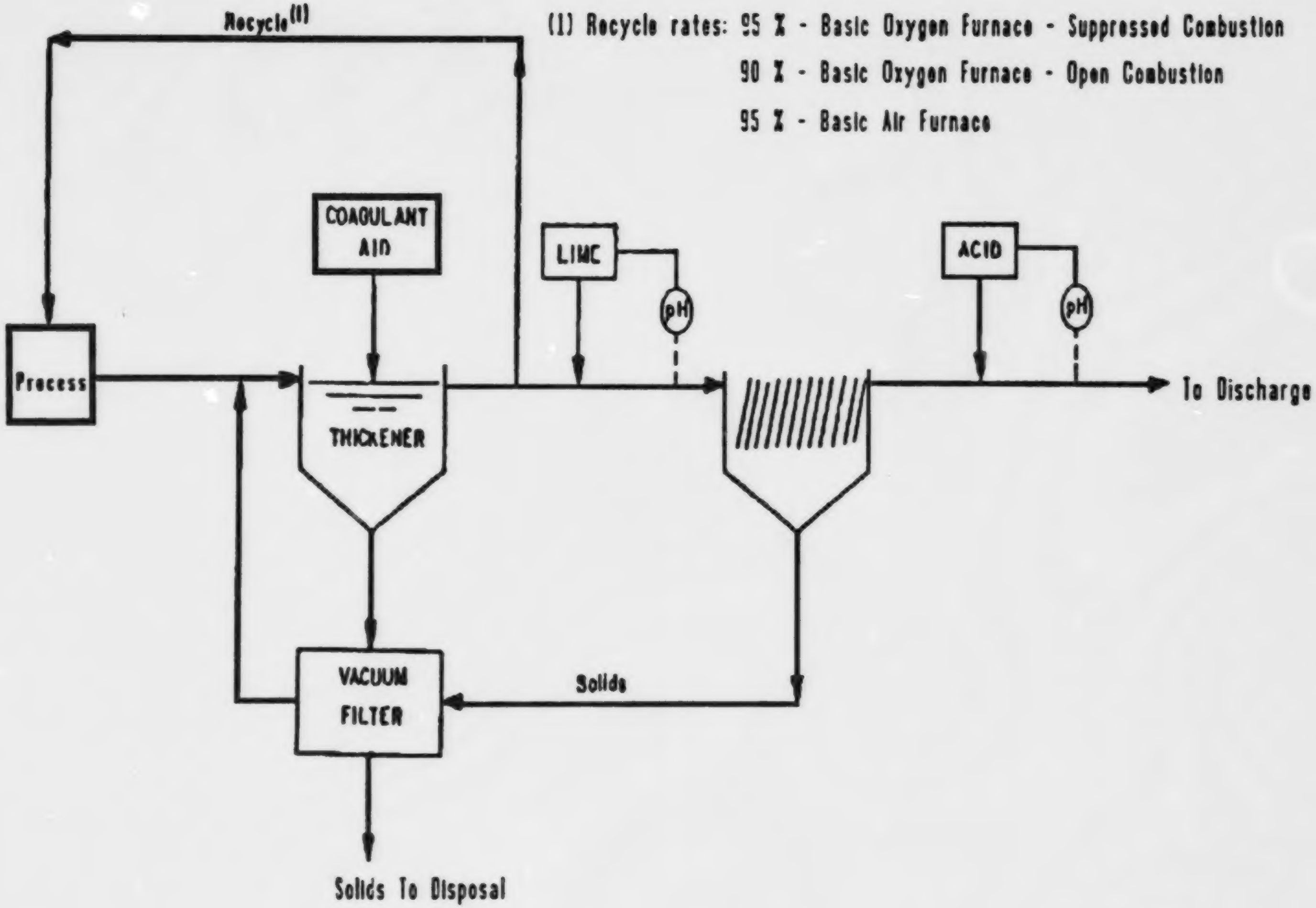
4.2.2.1 Wastewater

The water used for indirect cooling of the oxygen lance, furnace trunnion ring, nose cone, fume hood and other miscellaneous furnace components is not contaminated except for any blowdown from cooling towers. This blowdown is directed to a treatment plant.

The only significant source of wastewater is from the converter off-gas cooling and cleaning. While a few converter installations have used dry-type gas cleaning systems, the wet type is the most common.

The EPA wastewater treatment model, for both the open combustion and the suppressed combustion basic oxygen converter processes, consists of gravity sedimentation with the addition of a coagulant aid, lime addition to the discharge for metal and fluoride precipitation, final gravity sedimentation in inclined plate separators and a final pH adjustment to the treated water before discharge. A high recycling rate from the first gravity sedimentation unit reduces the amount of wastewater to be treated in subsequent steps. Sludge from both sedimentation units is de-watered in a vacuum filter with the filtrate returning to the inlet of the first gravity sedimentation unit and the sludge to disposal.

The EPA model flowsheet for this process is shown in Figure 4.2.2.1 and the EPA effluent standards are shown in Table 4.2.2.1.


Recycle(1)
COAGULANT AID
LIME
pH
ACID
pH
Process
THICKENER
To Discharge
VACUUM FILTER
Solids
Solids To Disposal

(1) Recycle rates: 95 % - Basic Oxygen Furnace - Suppressed Combustion
90 % - Basic Oxygen Furnace - Open Combustion
95 % - Basic Air Furnace

Figure 4.2.2.1 Steel Making - NSPS Effluent Model

TABLE 4.2.2.1 EPA BASIC OXYGEN FURNACE STEEL-MAKING NSPS STANDARDS

Segment and parameter		Concentration Basis (mg/L)	Effluent Standards (g/tonne)
WET-SUPPRESSED COMBUSTION			
Flow (L/tonne)		209	
pH (units)		6.0 to 9.0	
Total suspended solids	Avg.	25	5.22
	Max.	70	14.6
Lead	Avg.	0.3	0.0626
	Max.	0.9	0.188
Zinc	Avg.	0.45	0.0939
	Max.	1.35	0.282
WET-OPEN COMBUSTION			
Flow (L/tonne)		460	
pH (units)		6.0 to 9.0	
Total suspended solids	Avg.	25	11.5
	Max.	70	32.1
Lead	Avg.	0.3	0.138
	Max.	0.9	0.413
Zinc	Avg.	0.45	0.207
	Max.	1.35	0.620

Source: Development Document for Effluent Limitations Guidelines, New Source Performance Standards and Pretreatment Standards for the Iron and Steel Manufacturing Point Source Category. Volume III EPA 440/1-82/024, May 1982

The 1989 EPA New Source Performance effluent standards are shown in Table 4.2.2.2.

TABLE 4.2.2.2 EPA NEW SOURCE PERFORMANCE STANDARDS FOR BASIC OXYGEN FURNACE STEEL MAKING 1989

Segment and parameter	Effluent Standards (g/tonne of steel)	
	Maximum for any 1 day	Average of daily values for 30 consecutive days
WET-SUPPRESSED COMBUSTION		
pH (units)	6.0 to 9.0	
Total suspended solids	14.6	5.22
Lead	0.188	0.0626
Zinc	0.282	0.0939
WET-OPEN COMBUSTION		
pH (units)	6.0 to 9.0	
Total suspended solids	32.1	11.5
Lead	0.413	0.138
Zinc	0.620	0.207

Source: Federal Register, 40 CFR Ch. 1 (7-1-89 Edition) #420.34 New source performance standards (NSPS). (b) Basic oxygen furnace steelmaking -- wet-suppressed combustion and (c) Basic oxygen steelmaking -- wet open combustion.

4.2.2.2 Air Emissions

The major source of air emissions is the basic oxygen converter and the major quantity of converter air emissions is generated during the oxygen blowing cycle.

To collect the hot waste gases generated during the furnace operation, early basic oxygen converters used a large hood with a gap between the hood and the furnace. This type of hood aspirated a large volume of air and virtually all of the carbon monoxide in the off-gas was burnt, greatly increasing the volume of off-gas to be cleaned. The bath turbulence and violent slopping that characterized the earlier converter operations resulted in a slag build-up on the nose of the converter vessel that made it dangerous to lower the hood too close to the vessel lest the slag build-up freeze the hood to the vessel.

Improved process control reduced the violent slopping of the earlier converter installations and allowed the hood to be lowered closer to the converter vessel, decreasing the amount of aspirated air and the volume of off-gas that had to be cleaned. However, as the hood was moved closer to the converter vessel the carbon monoxide concentration increased in the off-gas. This type of operation is known as the suppressed combustion or "O-G" (off-gas) system and can be used with any of the various converter configurations - top blown, bottom blown or combination blown.

Additional improvements to process controls and improved converter operating practices made it feasible to locate the hood very close to the converter vessel, further reducing the aspirated air to a very small quantity, which, in turn, increased the carbon monoxide concentration in a reduced volume of off-gas. The carbon monoxide concentration became high enough that it had to be either flared or recovered for use as a fuel.

With the advent of the combination blown converter process, the bath in the converter vessel became more quiescent with less slopping and the slopping became less violent, making it feasible to lower the hood very close to the converter vessel without fear of slag build-up between the converter vessel and the hood.

A recent development is the combustion of some of the carbon monoxide before it enters the hood to release more heat into the bath and improve the thermal efficiency of the process.

Since oxygen rather than air is used for this combustion, the increase in volume of the off-gas is negligible but the carbon monoxide concentration is decreased. This variation is known as the post-combustion process.

The above factors constrain the design of the air pollution control system. The open-combustion process requires that a very large volume of off-gas be cleaned but the carbon monoxide concentration is low so either a dry-type collection system (eg. electrostatic precipitator) or a wet scrubber system may be used. Fabric filter systems have not been widely used because of the elevated off-gas temperature. With the suppressed combustion system and its higher carbon monoxide concentration, most steel plant operators avoided the dry-type collection systems thereby minimizing the risk of explosions. In Europe some dry-type collection systems are used for the suppressed combustion process.

In the wet-type collection system used for either the open combustion or suppressed combustion converter operations the hot off-gas is collected in a water-cooled structural hood located directly above the converter vessel. A moveable skirt is installed on the bottom of the hood so that the skirt moves down closer to the converter vessel during the blowing and refining periods and is raised to allow the converter vessel to tilt for other parts of the cycle. The hood cooling water may be used to produce steam in some installations. The off-gas then enters the quencher section where the it is cooled with water sprays. The coarse material in the off-gas is washed down to the bottom of the quencher and removed for treatment.

The gas is then cleaned in a high-energy venturi scrubber, 1500 mm water column or more, reducing the particulate concentration in the cleaned off-gas to less than 30 mg/Nm^3.

The cleaned gas is discharged to the atmosphere or to a gas holder for storage and distribution as a fuel. If the off-gas is discharged to the atmosphere, it must be flared when the CO concentration is high.

When the converter vessel is tilted for scrap or hot metal charging or for tapping, the emissions are not collected by the main hood system. Instead, secondary hoods are extended over or partly over the converter vessel to collect the emissions in the tilted position. These secondary hoods are also operated during the blowing and refining parts of the cycle to collect any fugitive emissions that escape the main hood. In modern oxygen converter shops, moveable panels are placed in front of and behind the converter to direct any fugitive emissions from those areas to the secondary hood. High-efficiency dry-type collection systems, usually fabric filter systems, are used for the secondary collection system since the gas temperature is not high and large volumes are collected. The hot metal transfer is hooded to collect the emissions from this source. These gases are usually cleaned in the converter secondary system since the hot metal transfer operation is intermittent.

Another source of air emissions is the flux handling system. All transfer points are hooded and the collected gas is cleaned in high-efficiency fabric filter systems.

The particulate emissions generated from the crushing and screening of the cooled slag are collected in a fabric filter system.

The controlled emission factors for the basic oxygen steel-making operations are shown in Table 4.2.2.3.

TABLE 4.2.2.3 **CONTROLLED PARTICULATE EMISSION FACTORS FOR BASIC OXYGEN STEEL MAKING**

		Emission Factors		
Source	Control Technology	Concentration (mg/Nm^3)	Process weight (kg/tonne of steel)	
		(3)	(3)	(4)
Melting and refining:				
Top blown				
Open hood	Wet scrubber	30	0.02 (1)	0.045
Closed hood	"	30		0.0034
Bottom blown	"	30		0.028
Combination blown				
Closed hood	"	30		0.004e
Charging	Fabric filter	20	0.04 (2)	0.0003
Tapping	"	20		0.0013
Slag pouring	"	20	0.005	
Hot metal transfer	"	20	0.0035	
Slag crushing and screening	"	20	0.005	

Notes: (1) No type specified

(2) Emission factor for charging, tapping and sampling

e Estimated

Source: (3) Handbook of Air Pollution Technology, John Wiley & Sons

(4) Compilation of Air Pollutant Factors Volume I: Stationary Point and Area Sources, Fourth Edition, Supplement B, 9/88

4.2.2.3 Solid Waste

Slag:

The processing of slag is usually carried out off-site by a third party, which is discussed in Section 4.7.2. When processed on-site, the slag is crushed and screened and the contained steel is removed by magnetic separation. The steel is recycled to the melt shop. Slag with a high lime content is often used as part of the flux charge to the blast furnace. The amount used depends on the operating practice of the plant. The balance of the slag is usually used as a construction material although high lime slags are weathered or processed to prevent swelling in use. One recent use is as aggregate for asphalt paving.

Secondary steel-making slags are usually disposed of in landfill sites.

Flue Dusts and Sludges:

The dust collected from the converter gas cleaning is often stockpiled since the high zinc content precludes its recycle to the blast furnace although it may be possible to recycle partially in a sinter plant. See Section 4.1.4.3 (Blast furnace solid waste) for a discussion of the processing for recycling waste dust.

The dust collected from the flux system may be recycled or may be disposed in landfill sites.

Miscellaneous solid wastes, such as broken refractory, are disposed in landfill sites.

4.2.3 Electric Furnace Steel Making

4.2.3.1 Wastewater

Dry-type fabric filter air pollution control systems are normally used for electric arc furnace steel making. The only wastewater stream is the blowdown from the cooling towers.

4.2.3.2 Air Emissions

The major air emissions from the melting and refining phases of the steel-making process are collected through a fourth hole in the roof. Door and tap hole fugitive emissions are captured by a secondary canopy hood above the furnace. This system is considered to be the most efficient design for the electric arc furnace.

Other types of hoods are used also. One is the side-draft hood which covers part of the roof and hoods the electrode openings in the roof. Hood extensions over the doors and tap hole capture fugitive emissions from these sources. Another is the primary canopy hood, which is located above the furnace and collects more air, increasing the size of the dust collector. The hood has to be sized to store the sudden surge of emissions during charging. The waste gas stream is ducted to a high-efficiency fabric filter system for dust removal.

Except when a primary canopy hood is used, a secondary canopy hood is located above the furnace to capture the emissions from charging when the roof including the hood is swung away from the furnace. This secondary hood is usually connected to the same fabric filter system as the main hood but is usually operational only when the main hood is disconnected from the collection system.

The minor emissions from scrap cutting and refractory repairs are not usually collected.

The controlled particulate emission factors are shown in Table 4.2.3.1.

TABLE 4.2.3.1 CONTROLLED PARTICULATE EMISSION FACTORS FOR ELECTRIC ARC FURNACE OPERATION

Source or operation	Control Technology	(1) Concentration (mg/Nm^3)	(2) Process weight (kg/tonne steel)	(3)
Melting, refining charging & tapping	Fabric filter	12	0.0215	0.455
Building fugitive emissions	Fabric filter	50		
Slagging	Fabric filter	50		0.005
Slag crushing & screening	Fabric filter			0.005

Source: (1) Federal Register, 40 CFR Ch. 1 (7-1-89 Edition) Subpart AAa -- Standards of Performance for Steel Plants: Electric Arc Furnaces and Argon-Oxygen Decarburization Vessels Constructed after August 7, 1983

(2) Compilation of Air Pollutant Emission Factors Volume 1: Stationary Point and Area Sources, Fourth Edition, Supplement B, AP-42, September 1988

(3) Handbook of Air Pollution Technology, John Wiley & Sons, 1984

4.2.3.3 Solid Waste

Flue Dust:

Because of the fine nature of the dust, the dust collected by the air pollution control system is mixed with water in a pug mill at the dust discharge of the dust collector. Disposal of the electric furnace dust is a major problem. Because the charge to the furnace is usually 100 percent scrap unless considerable pre-reduced material is used, any volatile impurities in the scrap tend to concentrate in the collected dust.

EPA, under RCRA, has classified electric arc furnace dust as K061 low-zinc hazardous waste, which precludes disposal to landfill sites without pre-treatment to reduce the content of cadmium (<0.14 ppm), total chromium (<0.14 ppm), lead (<0.24 ppm) and nickel (<0.32 ppm). The most promising technologies for the treatment of electric arc furnace dust to meet these EPA requirements are high temperature processes. See Section 4.1.4.3 for a discussion of dust treatment processes.

Slag:

The slag from the electric furnace operation is usually processed off-site (discussed in Section 4.7.2). The iron values are recovered for recycling. Part of the processed slag is used as construction material and the balance is disposed of in landfill sites.

Other:

The other solid wastes are primarily broken refractory that is disposed of in a landfill site.

4.2.4 Vacuum Degassing and Ladle Metallurgy

4.2.4.1 Wastewater

Vacuum Degassing:

The EPA wastewater treatment model for the vacuum degassing operation consists of a scale pit for gravity sedimentation, addition of lime, inclined plate separator for final gravity sedimentation and acid addition for pH control prior to discharge. A high recycling rate of 98 percent from the scale pit reduces the water discharge. The inclined plate separator underflow is treated in a filter to de-water the sludge and the filtrate is returned to the inlet of the lime-mixing unit.

The EPA effluent standards based on this model process are shown in Table 4.2.4.1

TABLE 4.2.4.1 EPA VACUUM DEGASSING NSPS EFFLUENT STANDARDS

Characteristic			Concentration (mg/L)	Effluent Standard (g/tonne steel)
Flow	(L/tonne)		104	
pH	(units)		6.0 to 9.0	
Total suspended solids		Avg.	25	2.61
		Max.	70	7.3
Lead		Avg.	0.3	0.0313
		Max.	0.9	0.0939
Zinc		Avg.	0.45	0.0469
		Max.	1.35	0.141

Source: Development Document for Effluent Limitations Guidelines, New Source Performance Standards and Pretreatment Standards for the Iron and Steel Manufacturing Point Source Category. Volume III EPA 440/1-82/024, May 1982

The EPA NSPS standards are shown in Table 4.2.4.2.

TABLE 4.2.4.2 EPA NEW SOURCE PERFORMANCE STANDARDS FOR VACUUM DEGASSING 1989

Pollutant or pollutant property	Effluent Standards (g/tonne of steel)	
	Maximum for any 1 day	Average of daily values for 30 consecutive days
pH (units)	6.0 to 9.0	
Total suspended solids	7.3	2.61
Lead	0.0939	0.0313
Zinc	0.141	0.0469

Source: Federal Register, 40 CFR Ch. 1 (7-1-89 Edition) #420.54 New source performance standards (NSPS). SUBPART E Vacuum Degassing Subcategory

Ladle Metallurgy:

The only wastewater source, if any, is the blowdown from the cooling tower. This small wastewater stream is treated in either the vacuum degassing or the steel-making treatment facility.

4.2.4.2 Air Emissions

Significant quantities of particulate emissions are generated if an electric furnace is used for ladle metallurgy. Since there is no fourth hole, a side-draft hood and fabric filter are used. A small quantity of NO_x is generated from ladle heating using natural gas. Normally no air emission controls are applied to the vacuum degassing operations.

4.2.4.3 Solid Wastes

The major solid waste is the sludge from the vacuum degassing wastewater treatment. This sludge is combined with the steel-making solid waste for treatment or disposal.

The solid waste from refractory repairs to ladles and the vacuum degassing vessel is disposed to a landfill site.

4.2.5 Teeming

4.2.5.1 Wastewater

The amount of wastewater generated is very small. The main pollutant is suspended solids. No local treatment is usually required and any wastewater generated is usually transported to the melt shop or other local wastewater treatment system for removal of the suspended solids.

4.2.5.2 Air Emissions

No air pollution controls are normally installed for the teeming operations unless leaded steel is being teemed. In the case of leaded steel, local hooding is used to capture the fumes for cleaning in a fabric filter. Particulate emissions are estimated at 0.03 kg/tonne of ingot produced for normal operations. The particulate concentration for leaded steel production, which is a small percentage of steel production, is usually less than 25 mg/Nm^3.

4.2.5.3 Solid Waste

The solid waste generated is principally refractory material suitable for disposal in a landfill site.

4.2.6 Continuous Casting

4.2.6.1 Wastewater

The only significant wastewater stream for continuous casting is from the cast product spray cooling and the torch cut-off. The other wastewater stream is the blowdown from the indirect cooling water cooling tower.

The EPA model treatment process for the wastewater stream consists of a scale pit equipped with oil and sludge removal facilities, lime precipitation, gravity sedimentation, inclined plate separator and acid addition for pH control prior to discharge. Approximately 99 percent of the filter effluent is recycled to the process. The oil reclaimed from the scale pit is forwarded to the waste oil treatment facility. The sludges from the scale pit and from the inclined plate separator are forwarded to a sludge treatment facility for de-watering.

The EPA effluent standards based on this model process are shown in Table 4.2.6.1, the model process is shown in Figure 4.2.6.1 and the NSPS standards are shown in Table 4.2.6.2.

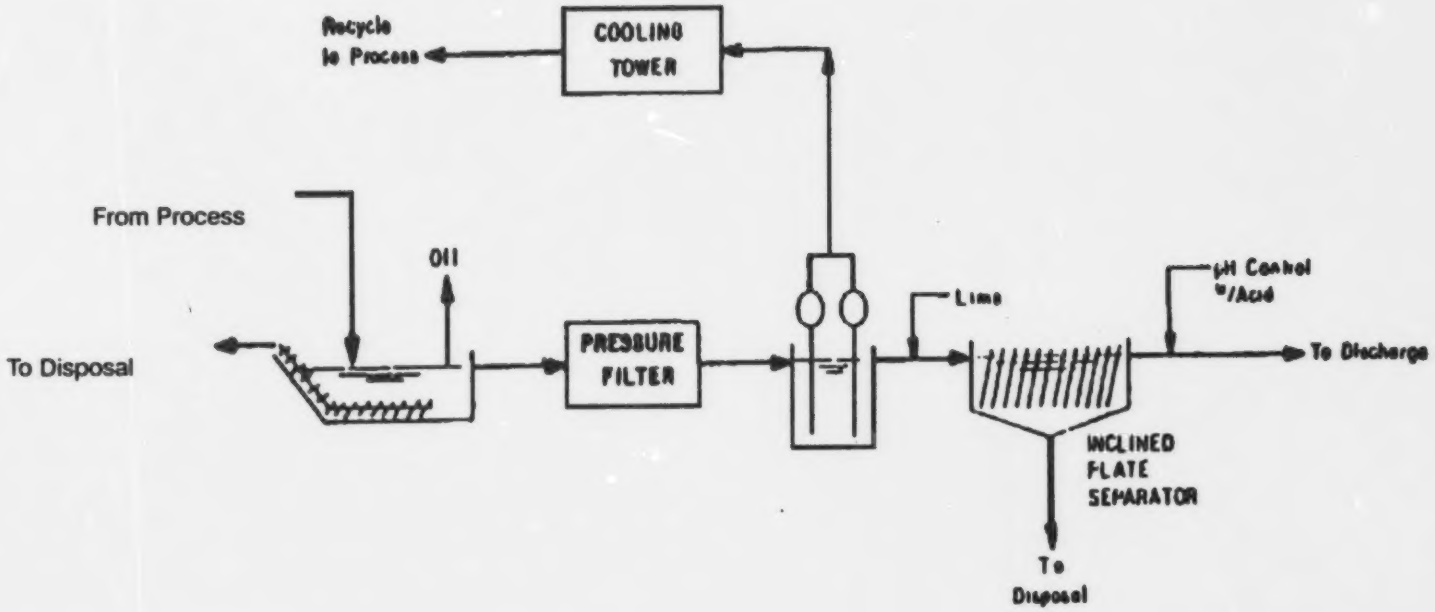

Recycle
to Process
COOLING
TOWER
From Process
Oil
To Disposal
PRESSURE
FILTER
Lime
pH Control
w/Acid
To Discharge
INCLINED
PLATE
SEPARATOR
To
Disposal

Figure: 4.2.6.1. Continuous Casting NSPS Effluent Model

TABLE 4.2.6.1 EPA CONTINUOUS CASTING NSPS EFFLUENT STANDARDS

Characteristic		Concentration (mg/L)	Effluent Standard (g/tonne steel)
Flow (L/tonne)		104	
pH (units)		6.0 to 9.0	
Total suspended solids	Avg.	25	2.61
	Max.	70	7.3
Oil and grease	Avg.	10	1.04
	Max.	30	3.13
Lead	Avg.	0.3	0.0313
	Max.	0.9	0.0939
Zinc	Avg.	0.45	0.0469
	Max.	1.35	0.141

Source: Development Document for Effluent Limitations Guidelines, New Source Performance Standards and Pretreatment Standards for the Iron and Steel Manufacturing Point Source Category. Volume III EPA 440/1-82/024, May 1982

TABLE 4.2.6.2 EPA NEW SOURCE PERFORMANCE STANDARDS FOR CONTINUOUS CASTING 1989

Pollutant or pollutant property	Effluent Standards (g/tonne of steel)	
	Maximum for any 1 day	Average of daily values for 30 consecutive days
pH (units)	6.0 to 9.0	
Total suspended solids	7.3	2.61
Oil & grease	3.13	1.04
Lead	0.0939	0.0313
Zinc	0.141	0.0469

Source: Federal Register, 40 CFR Ch. 1 (7-1-89 Edition) #420.54 New source performance standards (NSPS). SUBPART F Continuous Casting Subcategory

4.2.6.2 Air Emissions

The emissions of particulate from the ladle-casting area are captured by a local area hood and a high-efficiency fabric filter system. The fumes from the cut-off torches are not normally collected. The controlled particulate emission factor for the continuous casting operation is 0.005 kg per tonne of steel.

4.2.6.2 Solid Waste

The dust collected from the air pollution control system is estimated at 0.005 kg per tonne of steel and is normally combined with other dusts for disposal. The cut-off torch slag and water treatment system sludges, estimated at 0.3 kg per tonne of steel, are combined with the basic oxygen furnace sludges for disposal.

4.3 Hot Forming

4.3.1 Reheating

4.3.1.1 Wastewater

The furnace-component cooling-water cooling-tower blowdown should be directed to the mill-scale pit for treatment.

4.3.1.2 Air Emissions

Soaking pit and reheat furnace NO_x emissions are estimated to range from 190 mg/Nm^3 for gaseous fuels to 570 mg/Nm^3 for fuel oil. The emission factor is estimated at 0.8 kg per tonne of steel for fuel oil (1971 data). The control technology for NO_x is primarily low-NO_x burner design and combustion procedures. These reduce the NO_x emission factor by about 50 percent to 0.4 kg per tonne of steel for oil fuel.

Particulate emissions are generated primarily by the combustion process or by particulate contained in the fuel. Gaseous fuels produce very little particulate while fuel oil can emit up to 0.1 kg of particulate per tonne of steel. The particulate emissions are controlled by optimizing the operation of the combustion system, improved burner design and switching from fuel oil to gaseous fuels.

SO_x emissions vary according to the sulphur content of oil and are about 0.72 kg per tonne of steel for oil containing 1 percent sulphur. The control technology is to change fuels either to a lower sulphur content oil or to gaseous fuels or a combination of the two.

Available data on emissions of pollutants from soaking pits and reheat furnaces are shown in Table 4.3.1.1.

Table 4.3.1.1 AIR EMISSIONS FROM SOAKING PITS AND REHEAT FURNACES

Fuel and control technology	Particulate	SO_x	NO_x
	(kg/tonne steel)		
Fuel oil 1.0% sulphur:			
uncontrolled	0.1 (1)	0.72 (1)	0.62 (2)
controlled - ESP & burner design	0.015 (1)	0.72 (1)	0.35e
Coke oven gas (desulphurized) uncontrolled	0.005e	0.004 (2)	0.094 (2)
Controlled - burner design	0.005e	0.004 (2)	0.05e

Sources: (1) Handbook of Air Pollution Technology, John Wiley & Sons 1984

(2) Unpublished data from Canadian steel mill, 1988

e Estimated

4.3.1.3 Solid Waste

The solid wastes, primarily scale, are reported with the hot-rolling operation.

4.3.2 Surface Preparation

4.3.2.1 Wastewater

The large slag particles settle out in the automatic hot scarfing machine slag pit and are removed for disposal. The wastewaters from the automatic hot scarfing machine and the air pollution control system are directed to the mill-scale pit for treatment and are reported for the hot-rolling mill.

4.3.2.2 Air Emissions

The air pollution control technology is the wet electrostatic precipitator. The controlled particulate emission factor is 0.015 kg per tonne of steel.

4.3.2.3 Solid Waste

The solid wastes, scarfer slag and air pollution control sludge are combined with the hot-rolling mill-scale and treated in the hot-rolling mill treatment system.

4.3.3 Hot Rolling

4.3.3.1 Wastewater

The model process developed by EPA for their effluent regulation development for the hot-mill-scale pit effluent includes sedimentation of the raw wastewater in primary scale pits equipped with oil skimmers. Both the oil and the scale removed by this step are reclaimed. Between 60 and 75 percent of the scale-pit effluent is recycled to the process or other mill uses that do not require high-quality water. The balance of the scale-pit effluent is treated in a roughing clarifier with the clarifier underflow being de-watered in a vacuum filter. The effluent from the roughing clarifier is filtered to remove additional suspended solids and oil. The filter backwash is recycled to the roughing clarifier while the filter effluent is recycled for mill use. A cooling tower is used to reduce the recycling water temperature. The total recycling rate for this treatment model was 96 percent.

The flowsheet for this model treatment process is contained in Figure 4.3.3.1 and the EPA NSPS effluent standards based on this treatment model are contained in Table 4.3.3.1.

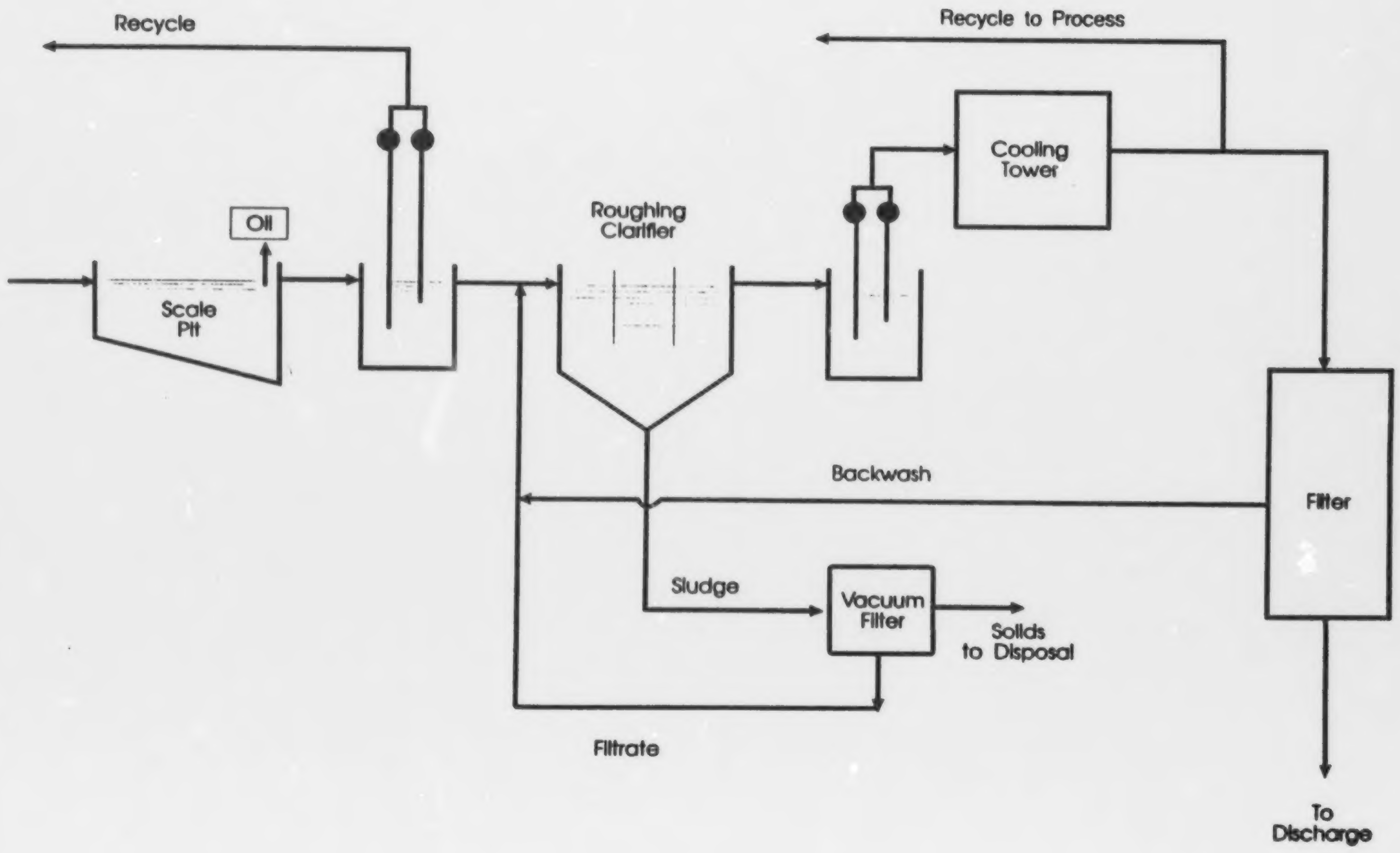

Recycle
Recycle to Process
Oil
Scale Pit
Roughing Clarifier
Cooling Tower
Backwash
Filter
Sludge
Vacuum Filter
Solids to Disposal
Filtrate
To Discharge

Figure 4.3.3.1 EPA Model Treatment - Hot Forming

TABLE 4.3.3.1 NSPS EFFLUENT STANDARDS HOT-FORMING SUBCATEGORY

Operations	Flow (L/tonne)	Suspended Solids		Oil and Grease	pH (units)
		(g/tonne)		(Daily)	
		Avg.	Max.	Max.	
Primary w/o scarfer	375	5.6	15.0	3.73	6-9
Primary with scarfer	585	8.8	23.4	5.84	6-9
Section	835	12.5	33.4	8.34	6-9
Hot Strip & Sheet	1,085	16.3	43.5	10.8	6-9
Plate	585	8.8	23.4	5.84	6-9
Pipe and Tube	920	13.8	36.9	9.17	6-9
All Hot-Forming Operations (mg/L)		**15**	**40**	**40**	

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume IV Hot Forming Subcategory, EPA 440/1-82/024, May 1982

The EPA new source performance standards (1989) for hot forming are shown in Table 4.3.3.2.

TABLE 4.3.3.2 EPA NEW SOURCE PERFORMANCE STANDARDS FOR HOT-FORMING SUBCATEGORY 1989

Pollutant or pollutant property	Effluent Standards (g/tonne of steel)	
	Maximum for any 1 day	Average of daily values for 30 consecutive days
(a) Primary mills:		
(1) Without scarfing		
pH (units)	6.0 to 9.0	
Total suspended solids	15.0	5.63
Oil & grease	3.73	....
(2) With scarfing		
pH (units)	6.0 to 9.0	
Total suspended solids	23.4	8.76
Oil & grease	5.84	....
(b) Section mills:		
pH (units)	6.0 to 9.0	
Total suspended solids	33.4	12.5
Oil & grease	8.34	....
(c) Flat mills:		
(1) Hot strip and sheet mills		
pH (units)	6.0 to 9.0	
Total suspended solids	43.5	16.3
Oil & grease	10.9	....
(2) Plate mills:		
pH (units)	6.0 to 9.0	
Total suspended solids	23.4	8.76
Oil & grease	5.84	....
(d) Pipe and tube mills:		
pH (units)	6.0 to 9.0	
Total suspended solids	36.9	13.8
Oil & grease	9.17	....

Source: Federal Register, 40 CFR Ch. 1 (7-1-89 Edition) #420.74 New source performance standards (NSPS). SUBPART G Hot Forming Subcategory

4.3.3.2 Air Emissions

No air pollution control is normally required for the hot-rolling operation. In some cases some fume and oil collection may be required to meet industrial hygiene requirements.

4.3.3.3 Solid Waste

The major solid wastes are the mill scale from the scale pit, sludge from the water treatment system and oil recovered in the water treatment system. The mill scale is usually charged into the blast furnace or sinter plant. The sludge from the water treatment system is usually recycled through a sinter plant, if one is available, or stockpiled, unless there is a treatment plant available. The total mill scale and sludge that are generated and collected, including the mill scale from the reheating furnaces and the slag and sludge from the scarfing machine, is 61.5 kg per tonne of steel. This quantity is being reduced by the increasing use of continuous casting.

The recovered oil is transported to an oil treatment plant for reclaim or disposal.

Some oil remains with the mill scale and sludge making it more difficult to recycle. At least one Japanese steel company (NKK) burns off the oil contained in the mill scale and sludge. A solvent extraction process using methylene to remove the oil has been developed but has not been demonstrated commercially. There are problems with fugitive solvent emissions from this process.

4.4 Cold Forming

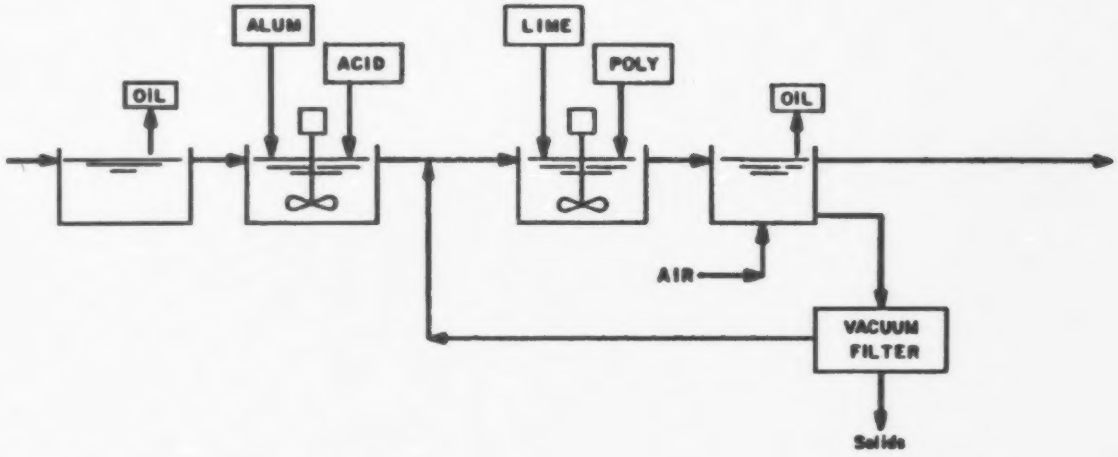
4.4.1 Cold Rolling

4.4.1.1 Wastewater

The model process developed by EPA for their effluent regulation development for the cold-rolling wastewater consists of an equalization basin equipped with an oil skimmer, chemical addition steps to break the oil emulsions, a flocculation tank and an air flotation system.

Oils and greases present in cold-rolling wastewaters are either emulsified or non-emulsified. Since the majority of the oils used are emulsified, chemical treatment is required to break the emulsion before further treatment. Either acid pickling rinse water or purchased acid is added to the oily cold-rolling wastewaters in a mixing tank at a pH of 4-5 to break the oil emulsions chemically. Then coagulant or flotation aids such as alum and polyelectrolytes may be added. The wastewaters are then neutralized and the oils are separated from the wastewater by air flotation, sedimentation and skimming or similar methods. If non-emulsified oils are present, oil skimming can be used for oil treatment.

Moderate levels of suspended solids are generated in cold-rolling operations. These solids are picked up on the rolls and carried from the process in the oil/water emulsions. In most cases the removal of suspended solids is carried out in clarifiers after the addition of lime and polymer in mixing tanks to promote settling and neutralize the wastewaters. A few mills use ultra-high-rate filtration after the removal of floating oils and heavy solids. The EPA treatment model is shown in Figure 4.4.1.1. The EPA effluent limitations and standards based on this model process for recirculating mills for either direct discharge or mixed treatment in the blowdown treatment plant are contained in Table 4.4.1.1.


ALUM
ACID
OIL
LIME
POLY
OIL
AIR
VACUUM FILTER
Solids

RECIRCULATION	
Single Stand (l/Tonne)	20
Multi Stand (l/Tonne)	39

Figure: 4.4.1.1 EPA Cold Rolling Treatment Model

TABLE 4.4.1.1 NSPS EFFLUENT STANDARDS COLD-FORMING SUBCATEGORY - COLD ROLLING

Parameter	Single Stand AVG	Single Stand MAX	Multi-Stand AVG	Multi-Stand MAX
a) Concentration (mg/L) unless otherwise noted:				
Flow (L/tonne)	21		42	
Total suspended solids	30	60	30	60
Oil and grease	10	25	10	25
Chromium	0.4	1.0	0.4	1.0
Lead	0.15	0.45	0.15	0.45
Nickel	0.3	0.9	0.3	0.9
Zinc	0.1	0.3	0.1	0.3
Naphthalene	-	0.1	-	0.1
Tetrachloroethylene	-	0.15	-	0.15
b) Effluent Limitations (g/tonne):				
TSS	0.63	1.25	1.25	2.5
Oil and Grease	0.21	0.52	0.42	1.04
Chromium	0.008	0.021	0.017	0.042
Lead	0.003	0.009	0.006	0.019
Nickel	0.006	0.019	0.012	0.038
Zinc	0.002	0.006	0.004	0.012
Naphthalene	-	0.002	-	0.004
Tetrachloroethylene	-	0.003	-	0.006

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume VI Cold Forming Subcategory, EPA 440/1-82/024, May 1982

The model process used as the basis of the proposed environmental control criteria for the cold-rolling operation is based on the system currently operating in a Canadian steel plant that is considered to be more advanced technologically than the EPA model. In this process the cold-rolling mill wastewater is stored in large heated storage tanks.

The wastewater is pumped in batches to a separating tank. Sulphuric acid is added to lower the pH to 1. After mixing and retention, the oil floats to the surface and is skimmed by gravity into an oil neutralization tank as a 50/50 oil/water mixture. The water remaining in the separating tank contains some solids, a trace of oil and often some of the emulsifiers and is pumped to a neutralization and solids removal system (This system also treats pickling rinse waters and other miscellaneous wastewaters. See Section 4.4.2 Pickling.). Additional biological treatment may be required to remove the emulsifiers.

The acidic oil/water mixture is pumped to the oil neutralization tank where caustic soda is added to raise the pH to 5.5. The balance is further processed in a centrifuge and the clean oil phase is used as a fuel in the plant or is further processed for recycle to the cold-rolling mill. The water phase is returned to the oil separation tank and the solid phase is sent to the neutralization solids removal system. A process flowsheet is shown in Figure 4.4.1.2.

4.4.1.2 Air Emissions

The mill exhaust filter system removes about 99 percent of the oil fumes generated during the rolling operation. No emission factor was located for this operation.

4.4.1.3 Solid Waste

The oil reclaimed from the wastewater treatment system is used as a fuel or upgraded for reuse in the rolling mill. The sludge from the wastewater treatment system is forwarded to the solids-separation treatment section. The scrap steel is recycled to the steel-making operation.

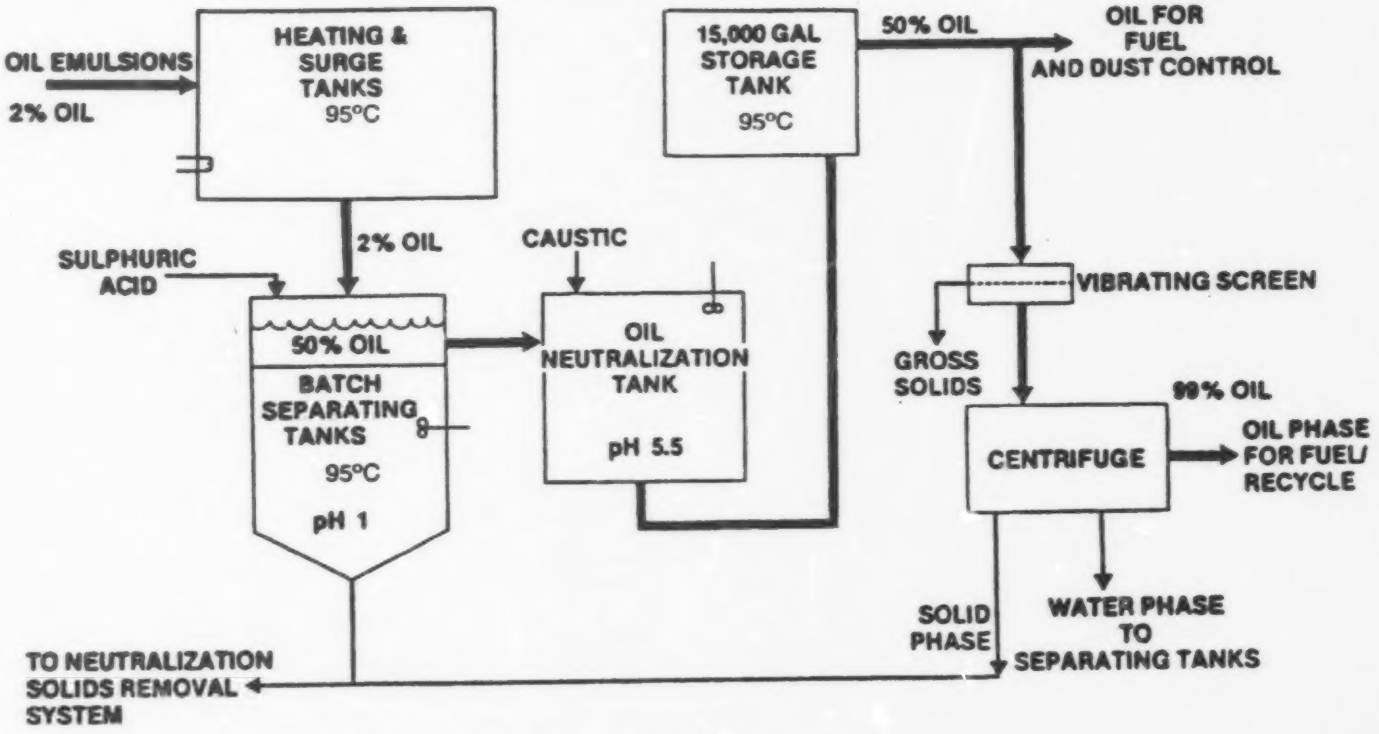

OIL EMULSIONS
2% OIL
HEATING & SURGE TANKS 95°C
2% OIL
SULPHURIC ACID
50% OIL
BATCH SEPARATING TANKS
95°C
pH 1
CAUSTIC
OIL NEUTRALIZATION TANK
pH 5.5
15,000 GAL STORAGE TANK
95°C
50% OIL
OIL FOR FUEL AND DUST CONTROL
VIBRATING SCREEN
GROSS SOLIDS
99% OIL
CENTRIFUGE
OIL PHASE FOR FUEL/ RECYCLE
SOLID PHASE
WATER PHASE TO SEPARATING TANKS
TO NEUTRALIZATION SOLIDS REMOVAL SYSTEM

Figure: 4.4.1.2 Cold Rolling Treatment Model

4.4.2 Acid Pickling

4.4.2.1 Wastewater

The model treatment process developed by EPA for their effluent regulation development for the acid pickling operation wastewater consists of spent acid neutralization, fume scrubber recycle, cascade rinsing, equalization of all wastewaters, oil separation, lime precipitation/neutralization, flocculation with polymer, aeration, clarification and vacuum filtration of the clarifier underflow. The EPA effluent limitations and standards based on this model process are contained in Table 4.4.2.1.

TABLE 4.4.2.1 NSPS EFFLUENT STANDARDS - ACID PICKLING SUBCATEGORY

Parameter	Concentration Basis (mg/L)		Effluent Standards (g/kkg of Product)	
	Avg.	Max.	Avg.	Max.
Sulphuric Acid				
Strip/Sheet/Plate				
Flow (L/tonne)	167			
Total suspended solids	30	70	5.0	11.7
Oil and grease (1)	10	30	1.67	5.0
Lead	0.15	0.45	0.025	0.075
Zinc	0.1	0.3	0.017	0.050
pH (units)	6.0 - 9.0		6.0 - 9.0	
Fume Scrubber (2)				
Flow (L/min)	62			
Total suspended solids	30	70	2.46	5.73
Oil and grease (1)	10	30	0.82	2.46
Lead	0.15	0.45	0.0123	0.037
Zinc	0.1	0.3	0.0082	0.025
pH (units)	6.0 - 9.0		6.0 - 9.0	

TABLE 4.4.2.1 (continued) NSPS EFFLUENT STANDARDS - ACID PICKLING SUBCATEGORY

Parameter	Concentration Basis (mg/L)		Effluent Standards (g/kkg of Product)	
	Avg.	Max.	Avg.	Max.
Hydrochloric Acid				
Strip/Sheet/Plate				
Flow (L/tonne)	167			
Total suspended solids	30	70	5.0	11.7
Oil and grease (1)	10	30	1.67	5.0
Lead	0.15	0.45	0.025	0.075
Zinc	0.1	0.3	0.017	0.050
pH (units)	6.0 - 9.0		6.0 - 9.0	
Fume Scrubber (2)				
Flow (L/min)	57			
Total suspended solids	30	70	2.46	5.73
Oil and grease (1)	10	30	0.82	2.46
Lead	0.15	0.45	0.012	0.37
Zinc	0.1	0.3	0.0082	0.025
pH (units)	6.0 - 9.0		6.0 - 9.0	

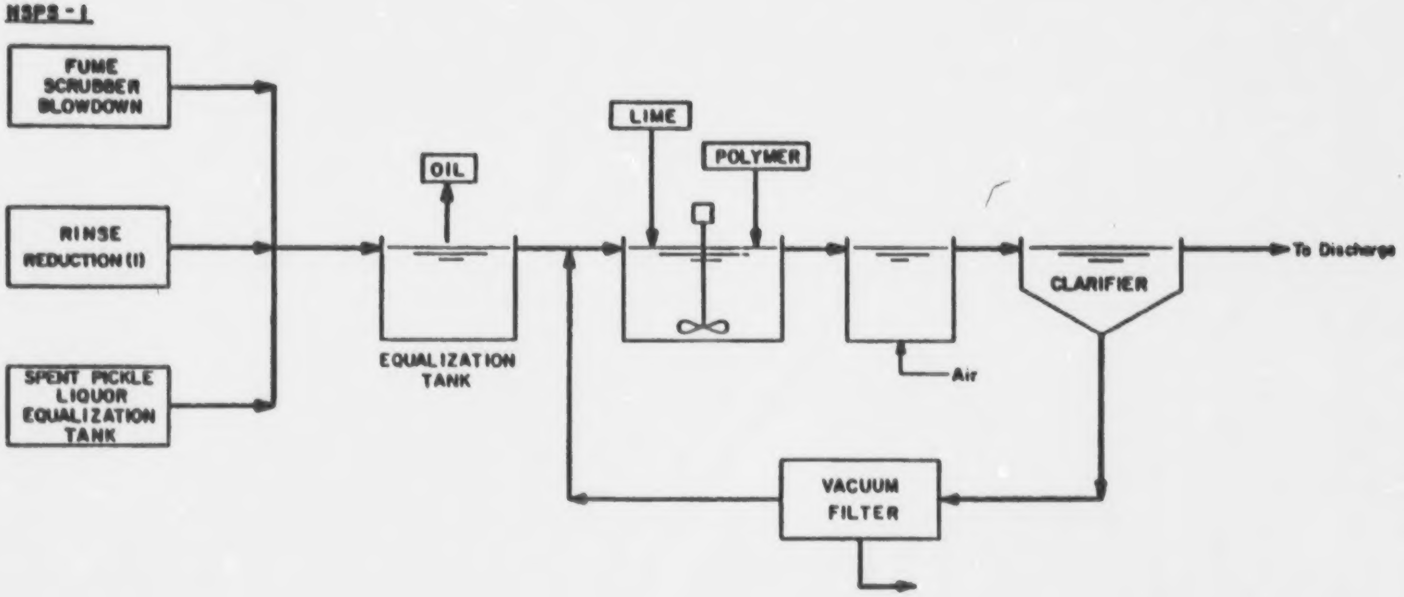
Notes:

(1) Oil and grease is limited only when pickling wastewater is treated in combination with cold-rolling wastewater.

(2) The fume scrubber limitations/standards which are given in kg/day are in addition to the limitations/standards shown for each pickling subdivision.

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume V Acid Pickling Subcategory, EPA 440/1-82/024, May 1982

The flowsheet for this model treatment process is shown in Figure 4.4.2.1.


NSPS - 1
FUME SCRUBBER BLOWDOWN
RINSE REDUCTION (1)
SPENT PICKLE LIQUOR EQUALIZATION TANK
OIL
EQUALIZATION TANK
LIME
POLYMER
Air
CLARIFIER
To Discharge
VACUUM FILTER

(1) Reduces Rinse Flow By 90%.

Figure: 4.4.2.1 EPA Model Treatment Process - Acid Pickling

Hydrochloric Acid Regeneration:

Hydrochloric acid regeneration is now a proven technology that eliminates the spent pickle liquor waste from hydrochloric acid pickling and recycles the regenerated acid. In hydrochloric acid pickling the iron oxide scale is dissolved as ferrous chloride. The waste pickle liquor containing water, ferrous chloride and unreacted HCl flows from the pickle line to storage tanks and is then pumped to the acid-regeneration plant. This waste liquor has a composition of approximately 3 percent HCl and 9 percent iron.

Acid regeneration is achieved by the conversion of ferrous chloride in the presence of oxygen at high temperature to HCl vapours which are later absorbed as hydrochloric acid and iron oxide in the form of small pellets of fine dust. The regenerated HCl is pumped back to the pickle line to maintain the acid strength in the pickle tanks. The regenerated acid strength is approximately 18 percent HCl. This provides approximately 90 percent of the total acid requirement for pickling. The balance is purchased as make-up.

The acid-regeneration process consists of a high-temperature reactor (usually either a spray roaster or fluidized bed reactor), cyclone separator, acid absorber, tail-gas scrubber and exhaust fan. The chemical reaction takes place in the high-temperature reactor where the ferrous chloride is converted to HCl vapours and iron oxide. In the case of the spray roaster, the iron oxide exits the reactor with the acid gas and is removed in the cyclone separator in the case of the fluidized bed reactor, the iron oxide pellets grow in the reactor and are removed from the bottom of the reactor. The iron oxide fines are collected in the cyclone separator and are returned to the reactor.

In both systems the acidic gases are cooled and the HCl vapours are absorbed in water in the absorber and are discharged as 18 percent hydrochloric acid, which is recycled to the pickle line. The tail gases leaving the absorber are scrubbed to remove the remaining traces of HCl vapour and the scrubber water is treated before discharge.

A typical flow diagram for the hydrochloric acid regeneration process (fluidized bed reactor) is shown in Figure 4.4.2.2.

New technology developments in pickling and acid regeneration technology further reduce the wastewater discharge from the pickling operation.

Modern pickle lines can be built and operated with counter-current cascaded rinse systems that operate close to a 100 percent recycling rate, reducing the wastewater flow to a minimum. New pickle tanks are designed with water-sealed polypropylene covers and operate with a negative pressure fume exhaust and fume scrubber system. These features reduce the volume of air that must be scrubbed, which in turn reduces the water requirements of the scrubber. When a high water-recycle rate is coupled with the smaller scrubber-water volume, the wastewater discharge is reduced even further.

4.4.2.2 Model Treatment Process

A model treatment process has been developed based on the EPA model treatment process, hydrochloric acid regeneration and pickle line improvements. This model process consists of a hydrochloric acid-regeneration plant, counter-current cascaded rinse system with minimum blowdown, sealed pickle tanks with high recycle scrubber and high water recycle on the acid-regeneration plant scrubber. The wastewater from these units is directed to the central cold-mill wastewater treatment plant (described in Section 4.6.1) for treatment.

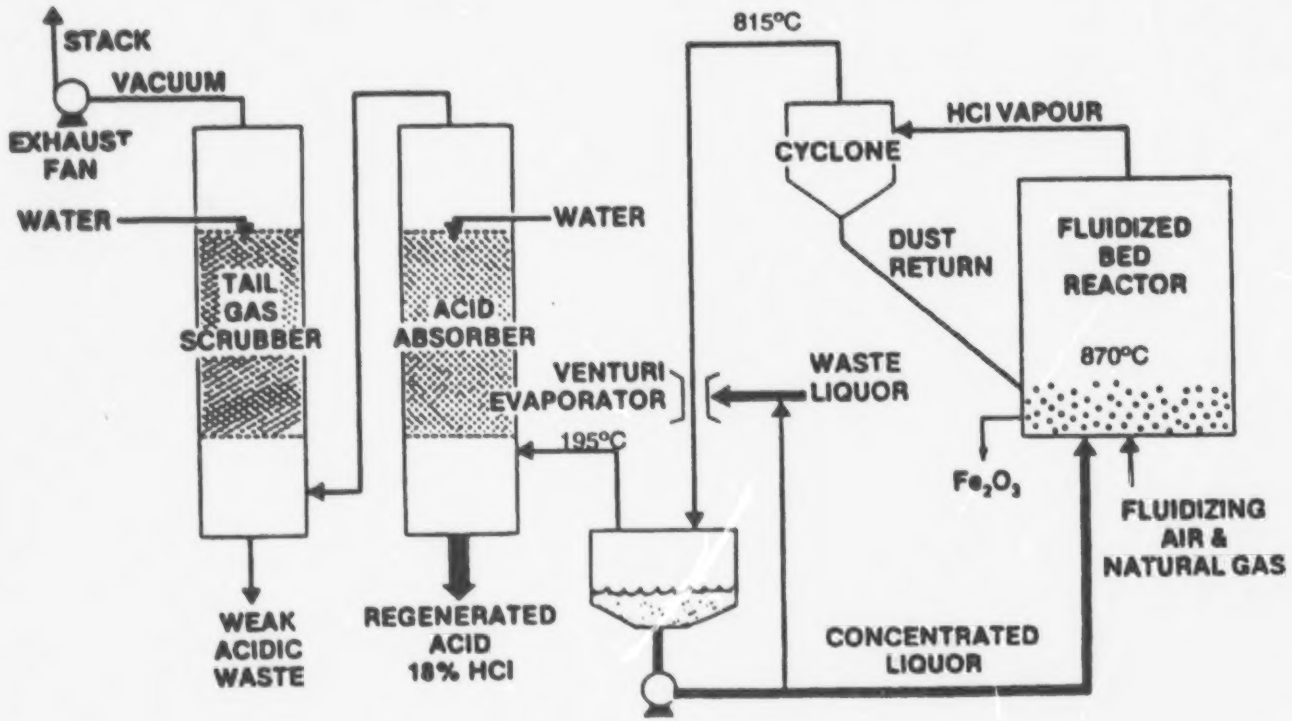

STACK
VACUUM
EXHAUST FAN
WATER
TAIL GAS SCRUBBER
WEAK ACIDIC WASTE
WATER
ACID ABSORBER
REGENERATED ACID 18% HCl
VENTURI EVAPORATOR
195°C
815°C
CYCLONE
HCl VAPOUR
DUST RETURN
WASTE LIQUOR
FLUIDIZED BED REACTOR
870°C
Fe2O3
FLUIDIZING AIR & NATURAL GAS
CONCENTRATED LIQUOR

Figure: 4.4.2.2 Hydrochloric Acid Regeneration System

4.4.2.3 Air Emissions

Wet scrubbers are used to collect the air emissions from the pickle tank fume scrubber and the HCl acid-regeneration plant vent. The particulate emissions from these two sources can be reduced to 20 mg/Nm^3 or approximately 0.002 kg per tonne of steel pickled. The HCl fumes can be reduced to 5 mg/Nm^3 or 0.0005 kg/tonne of steel pickled.

4.4.2.4 Solid Waste

The use of the HCl acid-regeneration process eliminates any requirement for disposal of spent pickle liquor. The only solid waste generated by the pickling operation is the iron oxide material from the HCl acid-regeneration process. This material is normally sold as a by-product or recycled within the plant.

Spent acid pickle liquor is designated as a special waste (Type 81) under the British Columbia Special Waste Regulation. If an acid pickling line operates without an acid-regeneration plant, the handling, treatment and disposal of the spent pickle are subject to provisions of the Regulation. Lime sludge from the treatment of spent acid pickle liquor is also classed as a special waste (Type 82) under the Regulation and is subject to the same provisions.

4.4.3 Alkaline Cleaning

4.4.3.1 Wastewater

The model treatment process developed by EPA for their effluent regulation development for the alkaline-cleaning operation wastewater consists of equalization with oil skimming, neutralization with acid and flocculation with polymer. Clarification provides solids removal followed by vacuum filtration for de-watering the sludge collected in the clarifier. This model process is based on a high level of recycle.

A similar system in a Canadian steel mill mixes the alkaline-cleaning wastewater with pickling rinse water and the effluent from the cold-rolling mill oil removal system. The resulting mixture is slightly acidic. Two-stage neutralization with lime slurry is carried out, followed by clarification. The clarifier sludge is de-watered in a thickener. The sludge from the thickener is further de-watered in a vacuum filter. The oil is skimmed from the clarifier. The thickener overflow and the vacuum filtrate water are returned to the entry mixing flume.

The toxic metal concentrations are low in the incoming wastewater and some are removed with the sludge; consequently EPA did not consider the toxic metal concentration of the treated water high enough to require either effluent limitations or subsequent treatment.

Ultrafiltration of the alkaline cleaning solution allowing its reuse is an emerging technology that reduces the wastewater generation by increased recycling.

The flowsheet for the model treatment process developed by EPA for the alkaline-cleaning operation is shown in Figure 4.4.3.1. The EPA effluent limitations and standards based on this model process are contained in Table 4.4.3.1.

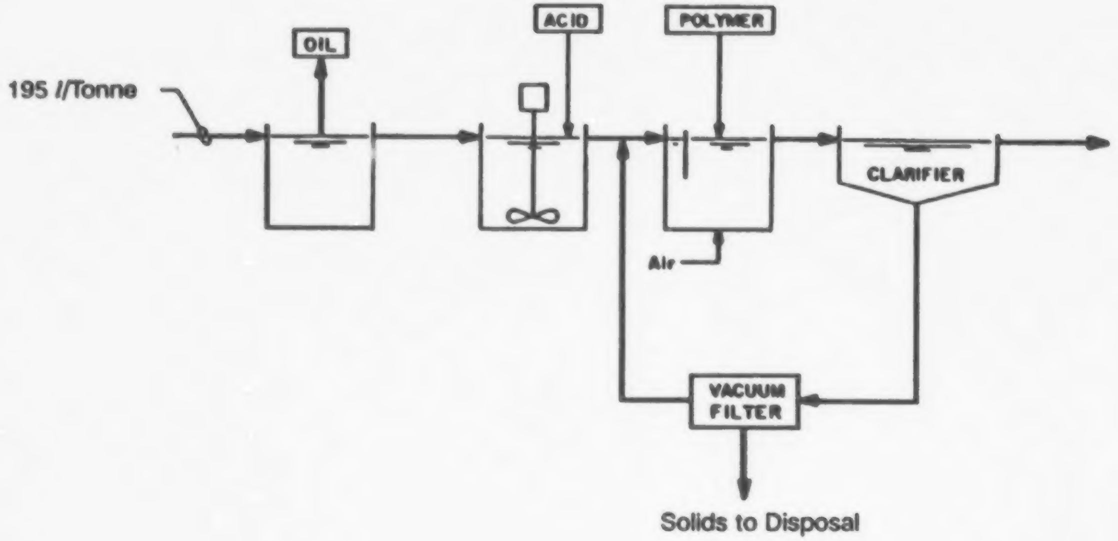

195 l/Tonne
OIL
ACID
POLYMER
Air
CLARIFIER
VACUUM FILTER
Solids to Disposal

Figure: 4.4.3.1 EPA Alkaline Cleaning Treatment Model

TABLE 4.4.3.1 NSPS EFFLUENT STANDARDS ALKALINE CLEANING SUBCATEGORY

Parameter		Concentration Basis (mg/L)	Effluent Standards (g/kkg of Product)
Discharge Flow (L/tonne)		209	
Total suspended solids	Avg.	30	6.3
	Max.	70	14.6
Oil and grease	Avg.	10	2.1
	Max.	30	6.3
pH (units)		6.0 - 9.0	

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume VI Alkaline Cleaning Subcategory, EPA 440/1-82/024, May 1982

4.4.3.2 Air Emissions

There are no air emissions to be controlled from this operation.

4.4.3.3 Solid Waste

The only solid waste generated is the sludge from wastewater treatment. It is transferred to the cold-mill central-treatment plant.

4.4.4 Annealing

4.4.4.1 Wastewater

The only wastewater stream is the blowdown from the cooling towers which is directed to the blowdown-treatment plant.

4.4.4.1 Air Emissions

NO_x emissions from the combustion of the gaseous fuels can be reduced to below 200 mg/Nm^3 by the use of low-NO_x burners and combustion improvements.

4.4.4.3 Solid Waste

Solid wastes are not generated.

4.4.5 Coating

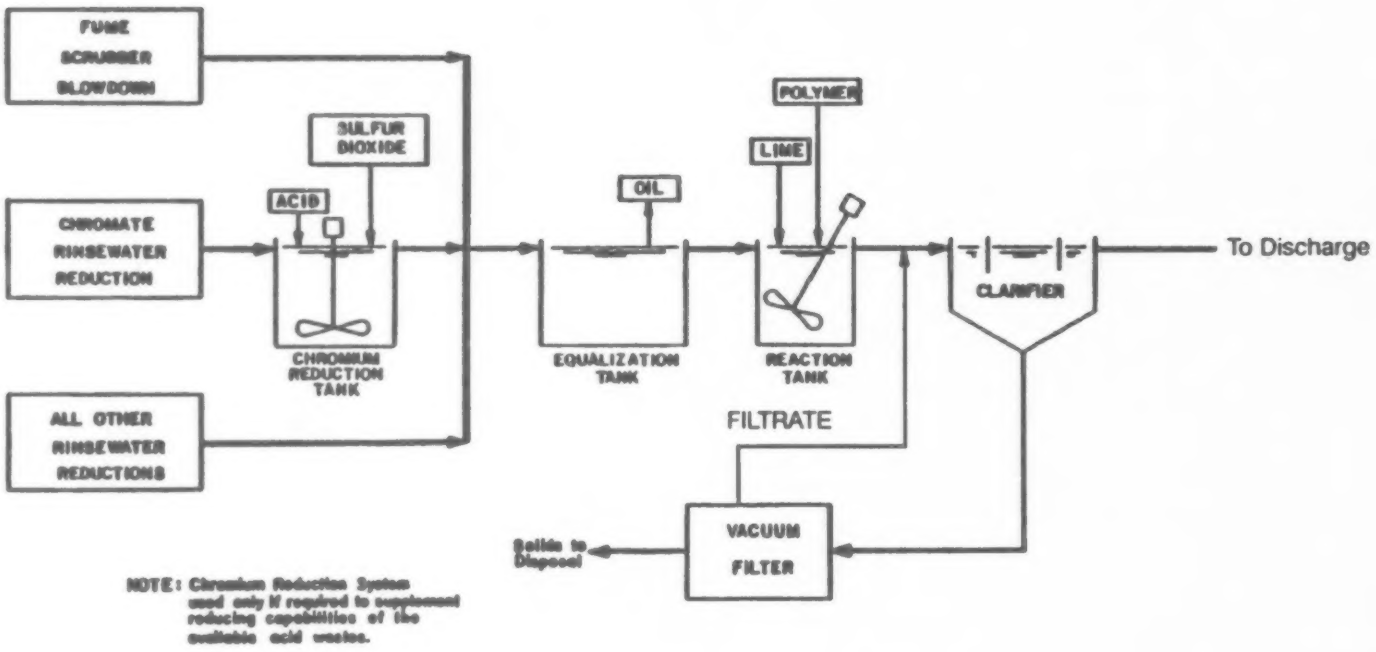
Only hot coating has been included in this section. Cold coatings, such as chromium and tin for tin plate for packaging, are specialized products and would be considered on a case-by-case basis. Strip and sheet painting lines are usually not included in an integrated steel plant and would be considered with other painting operations.

4.4.5.1 Wastewater

The model process developed by EPA for their effluent regulation development for the hot-coating operation wastewater consists of hexavelant chromium reduction for galvanizing operations with chromate rinses, oil removal, precipitation and flocculation with lime and polymers and clarification with vacuum filtration of clarifier underflow. This model process is based on a high level of recycling of rinse waters. Where fume scrubbers are used, the wastewater is treated in the same process. EPA set separate limits for the fume scrubbers because the fume scrubber effluent volume is not proportional to production volume. High recycling rates are also included for fume scrubbers.

The flowsheet for the model treatment process developed by EPA for the hot- coating operation is shown in Figure 4.4.5.1.

The EPA effluent limitations and standards based on this model process are contained in Table 4.4.5.1.


FUME SCRUBBER BLOWDOWN
CHROMATE RINSEWATER REDUCTION
ALL OTHER RINSEWATER REDUCTIONS
ACID
SULFUR DIOXIDE
CHROMIUM REDUCTION TANK
OIL
EQUALIZATION TANK
LIME
POLYMER
REACTION TANK
CLARIFIER
To Discharge
FILTRATE
VACUUM FILTER
Solids to Disposal

NOTE: Chromium Reduction System used only if required to supplement reducing capabilities of the available acid wastes.

Figure: 4.4.5.1 EPA Model Treatment Process - Hot Coating Operation

TABLE 4.4.5.1 NSPS EFFLUENT STANDARDS HOT COATING SUBCATEGORY

		Concentration Basis Coating Line (mg/L)	Effluent Standards	
			Coating Line (g/kkg of Product)	Add for Scrubber (kg/day)
Flow (L/tonne)			627	57 (1)
Total suspended solids	Avg.	30	18.8	2.45
	Max.	70	43.9	5.72
Oil & grease	Avg.	10	6.27	0.82
	Max.	30	18.8	2.45
Hexavelant Chromium (2)	Avg.	0.02	0.013	0.0016
	Max.	0.06	0.038	0.0049
Lead	Avg.	0.15	0.094	0.012
	Max.	0.45	0.282	0.037
Zinc	Avg.	0.1	0.063	0.0082
	Max.	0.3	0.188	0.0245
pH (units)		6.0 - 9.0	6.0 - 9.0	

Notes: (1) L/min.

(2) Applies only to galvanizing operations which discharge wastewater from a chromate rinsing step.

Reference: Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume VI Hot Coating Subcategory, EPA 440/1-82/024, May 1982

The wastewaters which are generated from the pickling operations (see Section 4.4.2) and from the alkaline-cleaning operations (see Section 4.4.3) are considered in the Sections noted.

4.4.5.2 Air Emissions

There are no significant air emissions to control.

4.4.5.3 Solid Waste

The only solid waste is the sludge from the wastewater treatment system, which is directed to the central cold-mill treatment plant for processing.

4.5 Utilities

4.5.1 Water Preparation and Distribution

4.5.1.1 Wastewater

The blowdown from the water treatment plant should be directed to the blowdown treatment plant.

4.5.1.2 Air Emissions

No air emissions are produced.

4.5.1.3 Solid Waste

No process solid waste is generated.

4.5.2 Steam Generation and Distribution

4.5.2.1 Wastewater

The blowdown from the boiler feedwater treatment system is neutralized and the solids are removed by gravity sedimentation. The blowdown from the sedimentation unit is directed to the blowdown treatment plant. The sludge is de-watered in a vacuum filter and the filtrate returned to the sedimentation unit.

4.5.2.2 Air Emissions

Particulate control is exercised through the selection of fuel and combustion techniques with an emission concentration of 60 mg/Nm^3 being achieved when a combination of blast furnace gas, coke oven gas and limited fuel oil is used. This is approximately 0.020 kg/tonne of steel.

SO_x control is exercised through the selection of fuel. A combination of blast furnace gas and coke oven gas will reduce SO_x emissions to about 0.001 kg/tonne of steel. Any use of fuel oil will increase the SO_x emissions by the amount of sulphur contained in the oil.

NO_x control is exercised through the selection of fuels and combustion techniques. The use of a combination of blast furnace gas and coke oven gas and NO_x-reduction combustion techniques and burners will reduce the NO_x emissions to:

• 100% blast furnace gas	0.060 kg/tonne of steel
• 100% coke oven gas	0.11 kg/tonne of steel

For a typical steel-plant fuel distribution of 70 percent blast furnace gas, 24 percent coke oven gas and 1 percent fuel oil, the NO_x emission factor is be 0.080 kg/tonne of steel.

4.5.2.3 Solid Waste

The only process solid waste is the sludge from the boiler feed water treatment system. The disposal of this material has to meet the requirements outlined in Section 5.3.

4.5.3 Fuel Storage and Distribution

4.5.3.1 Wastewater

The only wastewater is the process run-off water from the fuel oil storage area which is directed to the blowdown treatment plant and condensate from the coke oven gas drip legs which is collected for treatment in the coke oven water treatment system.

4.5.3.2 Air Emissions

No air emissions require control.

4.5.3.3 Solid Waste

There is no process solid waste.

4.5.4 Process Gases Production, Storage and Distribution

4.5.4.1 Wastewater

The blowdown from the cooling towers is directed to the blowdown final treatment plant.

4.5.4.2 Air Emissions

No air emissions require control.

4.5.4.3 Solid Waste

There is no process solid waste.

4.6 Central Wastewater Treatment Facilities

4.6.1 Cold Mill Central Wastewater Treatment

A cold mill central wastewater treatment plant has been developed by one Canadian steel plant using a variety of technologies to treat the various cold-mill wastewaters. This approach is considered to be more than equivalent to BAT. The flow diagram is shown in Figure 4.6.1.

The following wastewaters are treated in this plant:

1. Cold-mill oil emulsions
2. Pickling rinses
3. Cleaning rinses
4. Miscellaneous sump water

Cold-mill oil emulsions:

The cold-rolling-mill wastewater (oil-emulsion rolling coolants) is pumped from the rolling-mill area and is stored in heated storage tanks for equalization. The wastewater is pumped in batches to a separating tank where sulphuric acid is added to lower the pH to 1. After mixing and retention the oil floats to the surface and is skimmed by gravity into an oil-neutralization tank as a 50/50 oil/water mixture. The water remaining in the separating tank contains some solids and a trace of oil and is pumped to the neutralization and solids-removal section of the plant.

In the oil-neutralization tank caustic is added to raise the pH to 5.5. The 50/50 oil/water mixture can be recycled back to the cold mill or processed through a centrifuge for other uses, including as a fuel. The solids from the centrifuge are directed to the neutralization and solids-removal section and the dirty-water phase is returned to the separating tank.

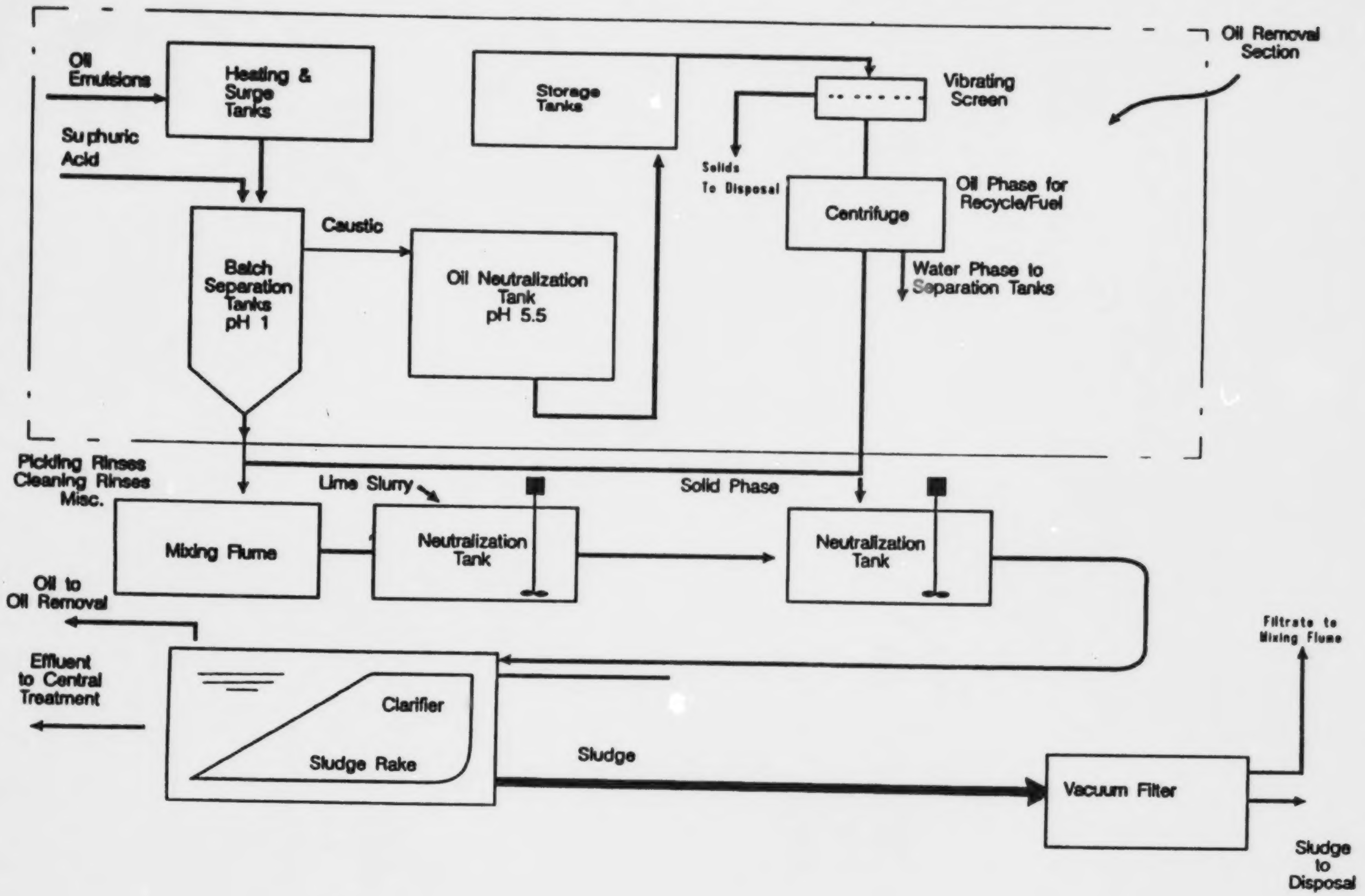

Oil Removal Section
Oil Emulsions
Heating & Surge Tanks
Suphuric Acid
Storage Tanks
Vibrating Screen
Solids To Disposal
Centrifuge
Oil Phase for Recycle/Fuel
Water Phase to Separation Tanks
Batch Separation Tanks pH 1
Caustic
Oil Neutralization Tank pH 5.5
Pickling Rinses Cleaning Rinses Misc.
Lime Slurry
Solid Phase
Mixing Flume
Neutralization Tank
Neutralization Tank
Oil to Oil Removal
Effluent to Central Treatment
Clarifier
Sludge Rake
Sludge
Vacuum Filter
Filtrate to Mixing Flume
Sludge to Disposal

Figure 4.6.1. Central Cold Mill Wastewater Treatment

Neutralization and solids removal system:

Weak acidic or alkaline wastewaters come from rinsing and fume-scrubber wastewaters from the pickling operations, alkaline-cleaning operations, cleaning sections of annealing and coating operations and miscellaneous other sources. The wastewaters from the various sources discharge into a mixing flume and flow by gravity into the primary neutralization tank. The mixture of wastewater streams is usually slightly acidic and lime slurry is added to raise the pH. In the secondary neutralization tank additional lime slurry is added to achieve a neutral pH. A chemical flocculent is added to aid in sedimentation.

The wastewater is then treated in a clarifier with a travelling sludge rake. Any oil remaining in the wastewater is collected on the surface of the clarifier and returned to the oil-emulsion section. The effluent is then discharged to the blowdown treatment plant. The sludge is de-watered for disposal (see Section 5.3 for disposal requirements) and the filtrate is returned to the mixing flume.

A third section of the presently-operating plant treats chromium-bearing wastes from electro-plating operations but is not included in this model process.

The effluent characteristics from the existing plant are shown in Table 4.6.1.1. The effluent is discharged to a municipal sanitary sewer. For a new plant, more stringent design criteria would substantially reduce the pollutant discharges from this plant.

TABLE 4.6.1.1 COLD MILL TREATMENT PLANT EFFLUENT CHARACTERISTICS (Annual average)

Pollutant	Concentration (mg/L)	Process Weight (g/tonne steel)
Flow 750 L/tonne		
TSS	108	81
Oil and grease	66.8	50
Carbon, dissolved organic	60	45
Lead	0.027	0.020
Zinc	0.14	0.11

Source: Personal communication.

Air Emissions

There are no air emissions that require control.

Solid Waste

The sludge from the wastewater treatment is the only solid waste that requires disposal. Refer to Section 5.3 for disposal requirements. The oil that is recovered is recycled within the plant.

4.6.2 Blowdown-Treatment Plant

The concept of a blowdown-treatment plant has been developed by a Canadian steel company. This concept is considered to be part of the overall BACT approach to steel-plant effluent treatment. The simplified flow diagram is shown in Figure 4.6.2.

The plant has two main sections: the chemical treatment section, which treats the effluent from the blast furnace treatment plant, and the coke oven biological treatment plant and the mechanical section which treats the effluent from the hot mill, steel-making and cold mill treatment plants and the effluent from the chemical section.

Chemical section:

The effluent from the blast furnace and coke ovens is mixed in an equalization tank. Caustic and polymer flocculant are then added to aid the sedimentation process that takes place in the flocculant/settlement unit. The sludge from the sedimentation is de-watered in a vacuum filter and the filtrate is recycled to the sedimentation unit while the solids are directed to disposal. The effluent is then acidified and chlorine is added to oxidize the residual ammonia and cyanide. The effluent is then discharged to the mechanical section for final treatment.

Cyanide chlorination may result in highly toxic intermediates (e.g., cyanogen chloride) and chlorinated organic materials. Careful control is required to minimize the formation of these materials. The use of peroxygen compounds, such as hydrogen peroxide, eliminates this problem but is much less efficient and effective in the reduction of low concentrations of cyanides in steel-plant wastewaters. Chlorination is still the optimum technology at the present time.

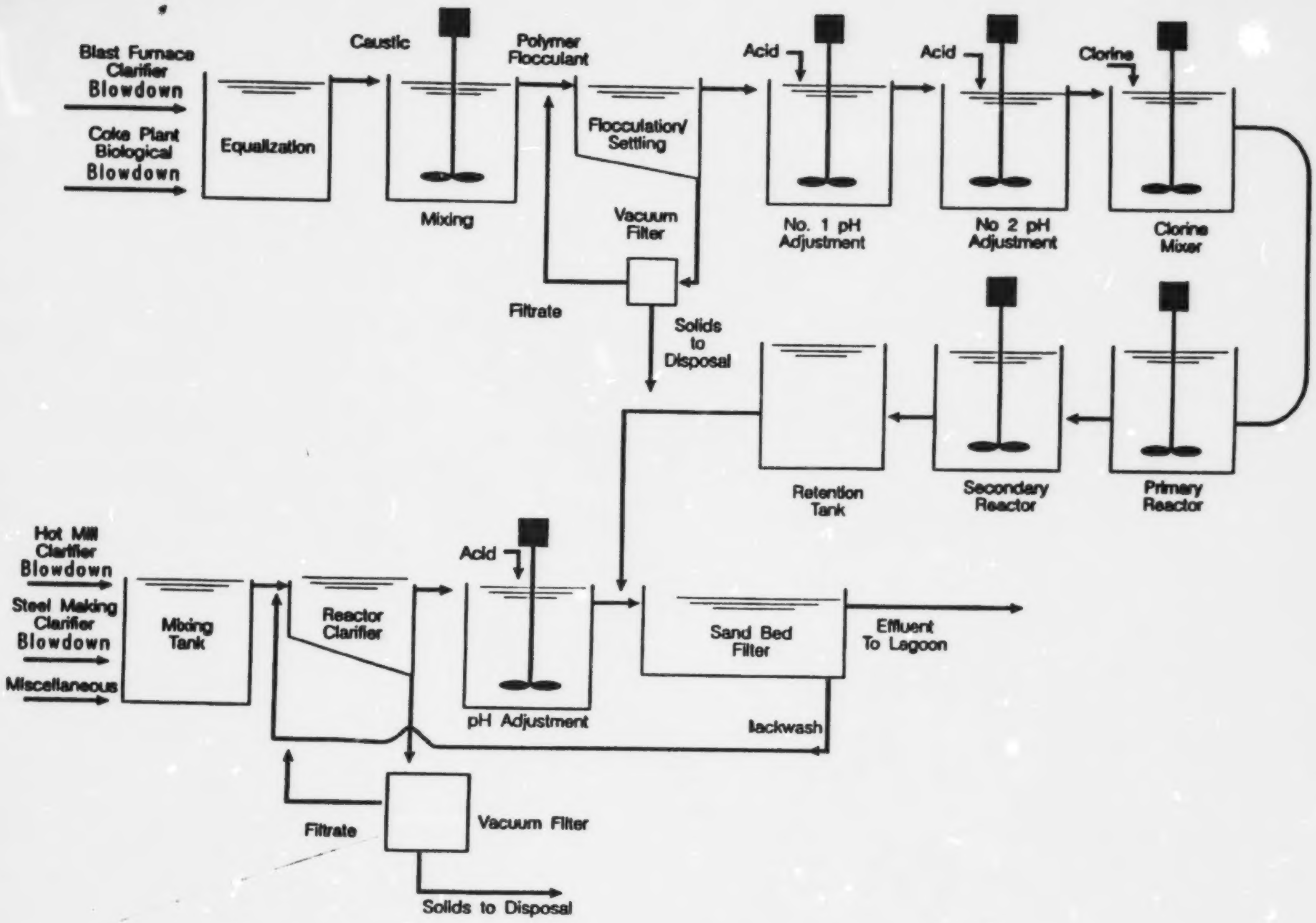

Blast Furnace Clarifier Blowdown
Coke Plant Biological Blowdown
Equalization
Caustic
Mixing
Polymer Flocculant
Flocculation/ Settling
Vacuum Filter
Filtrate
Solids to Disposal
Acid
No. 1 pH Adjustment
Acid
No 2 pH Adjustment
Clorine
Clorine Mixer
Primary Reactor
Secondary Reactor
Retention Tank
Hot Mill Clarifier Blowdown
Steel Making Clarifier Blowdown
Miscellaneous
Mixing Tank
Reactor Clarifier
Acid
pH Adjustment
Sand Bed Filter
Effluent To Lagoon
lackwash
Filtrate
Vacuum Filter
Solids to Disposal

Figure 4.6.2: Blowdown Treatment plant

Mechanical section:

The effluent from the steel-making treatment plant (hot-mill effluent is used as make-up in the steel-making plant) is mixed and discharged to a reactor clarifier for solids removal. The sludge is de-watered in a vacuum filter, the solids are sent to disposal and the filtrate is recycled to the reactor clarifier. Acid is added for pH adjustment and the effluent is discharged to a sand bed filter. The effluent from the chemical section is also filtered in the sand bed filter.

The backwash from the filter is returned to the inlet of the reactor clarifier and the effluent is discharged to a lagoon which, in turn, discharges to the receiving body of water. The effluent characteristics of the existing blowdown treatment plant are shown in Table 4.6.1.2.

TABLE 4.6.1.2 **BLOWDOWN TREATMENT PLANT EFFLUENT CHARACTERISTICS (Annual average)**

Pollutant	Concentration (mg/L)	Process Weight (g/tonne steel)
Flow 5,200 L/tonne		
TSS	8.4	44
Oil and grease	2.23	11.5
Cyanide	0.052	0.27
Ammonia N	0.13	0.67
Phenols (4AAP)	0.002	0.01
Chlorine (Free)	0.098	0.5
Lead	0.12	0.62
Zinc	0.19	1.0
Chromium	0.016	0.08
Copper	0.019	0.1
Cadmium	0.005	0.03
Phosphorus	0.30	1.5

Source: Personal communication.

Process run-off wastewater:

The process run-off wastewater is stored in a surge storage pond and is pumped to the blowdown treatment plant for treatment as required.

Air Emissions:

There are no air emissions requiring control.

Solid Waste:

The sludge from the vacuum filter is the only solid waste. See Section 5.3 for disposal of this waste.

4.7 Solid Waste Treatment and Disposal

4.7.1 Waste Oil and Grease Treatment and Reclamation

A wide range of lubricant-type materials - such as lubricating oils, process oils, hydraulic fluids and lubricating greases - is used in an integrated steel plant. The general classification of oils and greases is:

- petroleum-based oils and oils with similar composition
- rolling oils or emulsions, usually based on natural oils (discussed in Sections 4.4.1.1 and 4.4.1.3)
- synthetic lubricants
- synthetic fire-resistant hydraulic fluids (hydraulic fluids containing polychlorinated biphenyls [PCBs] have been used in existing steel plants but are being phased out and should not be used in new installations)
- greases for lubrication
- electrical transformer fluids (transformer fluids containing PCBs have been used in existing steel plants but are being phased out and should not be used in new installations)

Some of the oils and greases are directly recovered from mill sumps, compressors, fans and crank cases and usually contain some water. Treatment of these oils and greases is usually by gravity separation of the heated waste oil/water mixture followed by filtration, often using diatomaceous earths. Depending on the end use of the oil, further processing, including dehydration using sulphuric acid, may be required.

Oils and greases recovered by skimming of floating oils from water treatment plants is usually processed in a similar manner. Sometimes these two groups of oils are combined for treatment. Some steel plants reclaim only part or none of their waste oils and greases and ship them to commercial oil-reclaiming companies for treatment.

The end use of the reclaimed oils depends on the treatment process used and the quality of the reclaimed oil. Some is recycled for various uses (e.g., lubricating oil) and the balance is usually used as an in-plant fuel.

4.7.2 Off-site Slag Processing

Processing of both blast furnace and steel-making slag is usually carried out off-site by an outside contractor. The slag is crushed in a primary crusher and the larger pieces of iron and steel are recovered. The slag is then crushed in a secondary crusher and the balance of the iron and steel is recovered by magnetic separation. The slag is then final-crushed and screened to the appropriate sizes for sale or disposal.

Wastewater:

The only wastewater is the run-off from the processing and storage areas. The water is collected in settling ponds and part is reused for dust suppression while the balance evaporates.

Air Emissions:

Air emissions (particulate material) from the crushing and handling operations are controlled by the use of enclosed conveyors, hooding and fabric filters with a maximum discharge concentration of 20 mg/m^3. Dust suppression fluids (e.g., water) are used to control the fugitive-type particulate emissions generated by wind action, vehicular traffic and other activities.

4.7.3 Miscellaneous Solid Wastes

The miscellaneous solid wastes can be grouped in four classifications:

- by-products that are recycled or sold (These include coke breeze, tar, ammonium sulphate, sulphuric acid, ammonia, and sulphur from the coke ovens and iron oxide from the acid regeneration plant.)

- solid wastes, including refractory material (some may be recycled or sold for recycling), that are suitable for direct landfill

- solid wastes, including wood from construction and packaging and paper or cardboard from packaging and office use, that may be used as fuel or incinerated on site or disposed for recycling or incineration

- special wastes that require special disposal - including empty paint and solvent containers, used solvent, laboratory chemicals and empty chemical containers and mixed sludges from water treatment that contain hazardous or toxic materials. The sludge from the final wastewater treatment plant may fall into this category.

5.0 PROPOSED MODEL STEEL PLANT PROCESS and POLLUTION CONTROL CRITERIA

5.1 Unit Process Proposed Models (Wastewater)

5.1.0 Introduction

The overall wastewater treatment concept is that of a sequential integrated treatment system with the treatment of concentrated wastewater streams at the unit process source followed by the treatment of the blowdowns from the unit treatment plants, cooling towers and miscellaneous sources in the blowdown treatment plant. The conceptual model is based on high water-re-use and recycle rates and cascading of treated water from one unit process to another wherever feasible to minimize the volume of wastewater discharged from the plant. While this concept is used to develop the proposed pollution control criteria for wastewater, the designer of a plant for a specific site may use a different approach or concept provided that the discharged wastewater meets the proposed pollution control criteria.

A unit process treatment model for wastewater has been selected for each major production process. These process treatment models are based on those developed by EPA in their effluent standards development program.They were modified using information from examples of operating systems in Canadian steel plants and technologies reported elsewhere.

These models became the basic model from which the proposed pollution control criteria in Sub-section 5.2 were developed. The models are considered to be BACT unless otherwise specified. For example, the basic coke production model is considered to be BACT but the addition of a carbon absorption technology to reduce the level of residual organics would be considered to be LAER.

5.1.1 Coke Production

The proposed wastewater model treatment process is shown in Figure 5.1.1. The process is based on the background information in Sections 2.1.3, 3.1.3, 4.1.3 and Appendix C-1.0 as well as technologies that either eliminate or reduce the discharge of pollutants into the wastewater stream. Wastewater storage facilities are required before and after the biological treatment plant for use in emergency or upset conditions.

The wastewater quantity is reduced to the greatest extent possible by the selection of processes that eliminate or reduce wastewater generation. Examples of these processes are given below.

Production technologies:

- Indirect cooling of the coke oven gas to eliminate any contact of the process water with pollutants in the coke oven gas with the exception of the flushing liquor.

- Elimination of the recovery of naphthalene and the naphthalene sump.

Air pollution control technology considerations:

- Use of dry-type air pollution control technology for coal charging and coke pushing.

- Recovery of chemicals from the sulphur and HCN recovery processes for recycling or sale and the subsequent elimination of the wastewater stream.

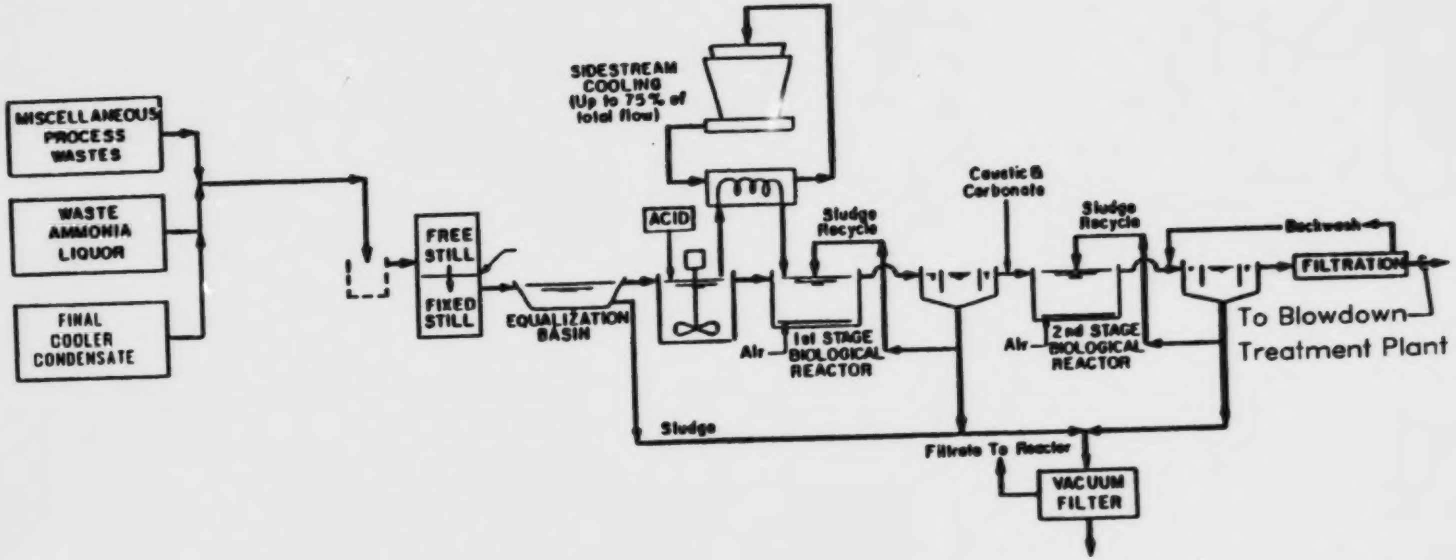

MISCELLANEOUS PROCESS WASTES
WASTE AMMONIA LIQUOR
FINAL COOLER CONDENSATE
FREE STILL
FIXED STILL
EQUALIZATION BASIN
SIDESTREAM COOLING (Up to 75% of total flow)
ACID
Air
1st STAGE BIOLOGICAL REACTOR
Sludge Recycle
Caustic & Carbonate
Air
2nd STAGE BIOLOGICAL REACTOR
Sludge Recycle
Backwash
FILTRATION
To Blowdown Treatment Plant
Sludge
Filtrate To Reactor
VACUUM FILTER

Figure: 5.1.1 Model Treatment Process - By-Product Coke Making

- Serious consideration should be given to the use of dry coke quenching to reduce the particulate emissions from the quenching operation.

Wastewater model treatment process:

The excess flushing liquor, wastewater streams from the by-product plant containing benzene, condensate from the final cooler, condensate from coke oven gas pipelines and wastewater from tar dehydration are treated in an ammonia still to remove ammonia. Caustic is used to recover the fixed ammonia and to eliminate sludge generation.

The effluent is pH adjusted and then is treated in a two-stage biological treatment process including a de-nitrification stage. Sludge recycle is used. The effluent is treated in a clarifier or similar sedimentation unit and the sludge is de-watered in a vacuum or equivalent filter and prepared for disposal. The filtrate is recycled to the sedimentation unit. The sedimentation unit effluent is filtered in a sand filter prior to discharge to the blowdown treatment plant. The filter backwash is recycled to the sedimentation unit.

This model process is considered to be BACT. However, if carbon absorption were added to the treatment train, it would be LAER.

5.1.2 Blast Furnace

The unit process proposed treatment model for the blast furnace wastewater is based on a high water-re-use and recycling rate. The process simplified flow diagram is shown in Figure 5.1.2. The wastewater streams from the blast furnace gas scrubber, slag pelletizing or granulating scrubber, de-kishing station scrubber and miscellaneous blast furnace sources are mixed in an equalization tank with lime addition. Solids are removed in a sedimentation unit where a flocculating agent may also be added. The sludge is de-watered in a vacuum filter or equivalent and the filtrate is returned to the sedimentation unit. Acid is added to the effluent to lower the pH. The effluent may be oxidized to remove organics before being directed to the blowdown treatment plant, depending on the concentration of the organics. If an oxidation step is included, the use of chlorine as the oxidizing agent should be minimized, if it cannot be avoided, in order to reduce or eliminate the possible formation of chlorinated organics in the effluent.

The basic process is considered to be BACT. The addition of the oxidizing step would be LAER as would the addition of a biological treatment step.

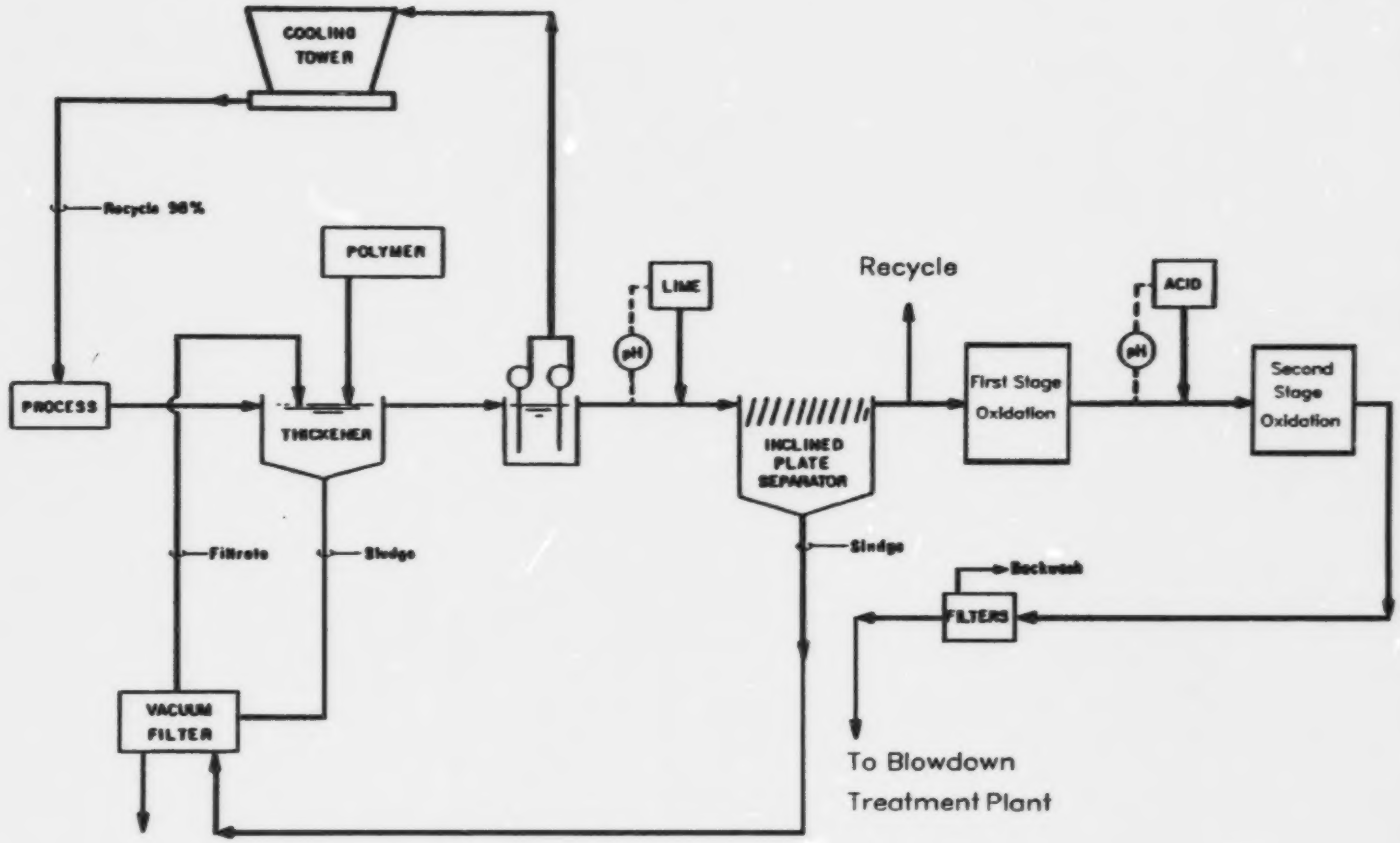

COOLING TOWER
Recycle 98%
POLYMER
PROCESS
THICKENER
Filtrate
Sludge
VACUUM FILTER
pH
LIME
INCLINED PLATE SEPARATOR
Sludge
Recycle
First Stage Oxidation
pH
ACID
Second Stage Oxidation
Backwash
FILTERS
To Blowdown Treatment Plant

Figure: 5.1.2 Model Treatment Process - Iron Making

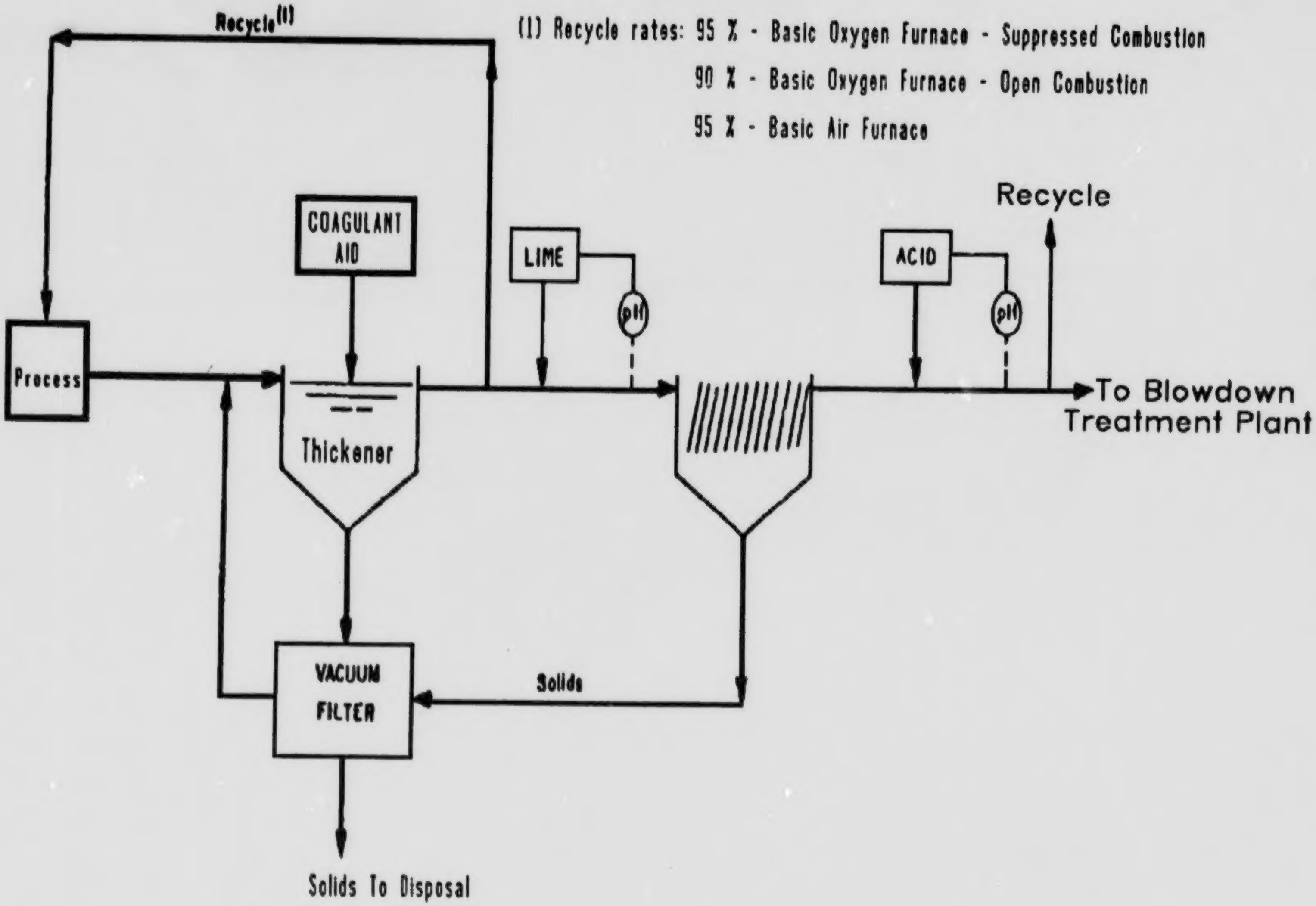
5.1.3 Basic Oxygen Steel Making

The model treatment process for basic oxygen steel-making wastewater is shown in Figure 5.1.3. The wastewater from the wet venturi scrubber is treated in a sedimentation unit with the addition of a flocculating agent as required. A blowdown stream from the sedimentation unit is directed to the blowdown treatment plant while the majority of the treated effluent is recycled to the wet scrubber. The sludge is de-watered in a vacuum filter or equivalent with the filtrate being recycled to the sedimentation unit. The water re-use and recycling rate is in excess of 95 percent.

The wastewaters of the continuous casting machine are treated in a sedimentation unit for solids removal with the effluent being recycled and the sludge being directed to the basic oxygen steel-making treatment plant for further treatment.

The wastewater from the vacuum degassing unit is directed to the basic oxygen steel-making unit for treatment.

This process is considered to be BACT.


Recycle$^{(1)}$
COAGULANT AID
Process
Thickener
LIME
pH
ACID
pH
Recycle
To Blowdown Treatment Plant
VACUUM FILTER
Solids
Solids To Disposal

(1) Recycle rates: 95 % - Basic Oxygen Furnace - Suppressed Combustion
90 % - Basic Oxygen Furnace - Open Combustion
95 % - Basic Air Furnace

Figure 5.1.3 Model Treatment Process - Steel Making

5.1.4 Hot Forming

The hot-forming wastewater model treatment process is shown in Figure 5.1.4. The wastewater from the hot mills, primary and secondary, is directed to the scale pit where the larger solids settle and floating oil is skimmed off for recovery. The effluent from the scarfer scale pit and fume scrubber are also discharged to the scale pit. The major portion of the scale pit effluent is recycled to flume flushing and the blowdown is directed to the hot-mill treatment plant. The initial solids removal is in a sedimentation unit with travelling sludge rakes and oil skimming.

The effluent is filtered in dual-media filters and recycled to the hot mill. The filter backwash is treated in a lamella-type sedimentation unit or equivalent with the effluent being returned to the filters. The sludge from both sedimentation units is de-watered in a vacuum filter or equivalent with the filtrate being recycled to the filters. A portion of the effluent from the sedimentation unit is directed to the steel-making water system as make-up for the gas cleaning system. The total water re-use and recycling rate is approximately 98 percent.

This process is considered to be BACT.

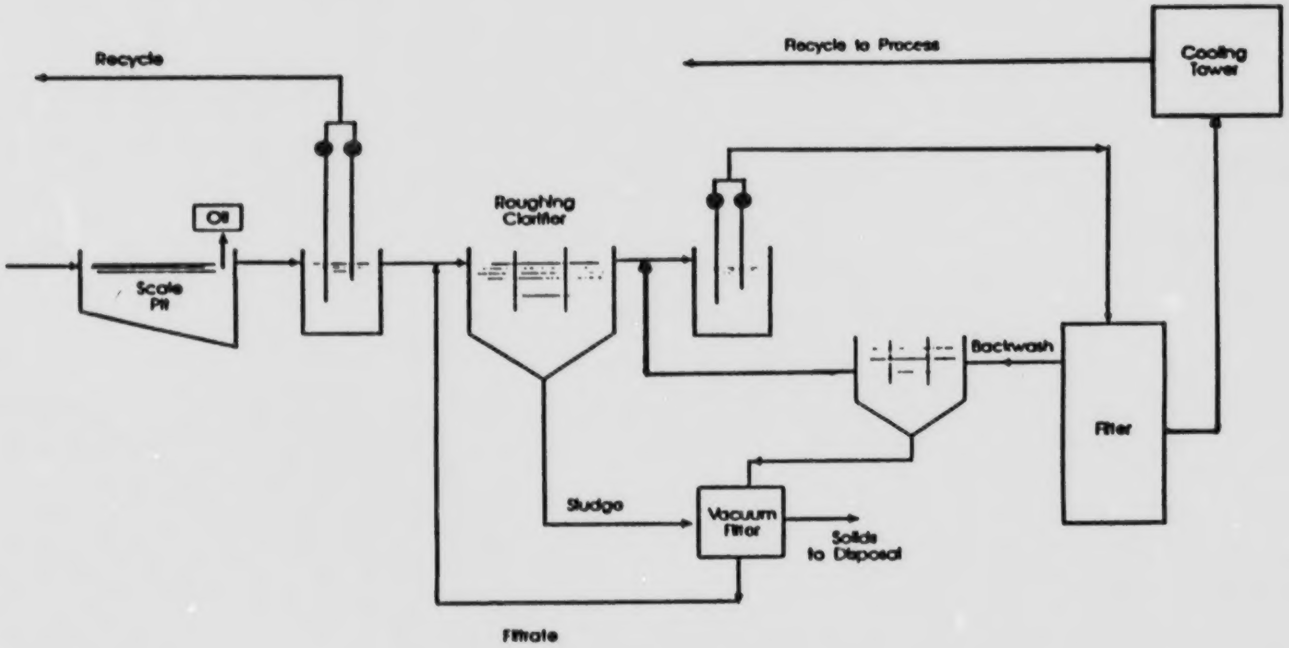

Recycle
Oil
Scale Pit
Roughing Clarifier
Recycle to Process
Cooling Tower
Backwash
Filter
Sludge
Vacuum Filter
Solids to Disposal
Filtrate

Figure: 5.1.4 Model Treatment - Hot Forming

5.1.5 Cold Mill Central Wastewater Treatment

The cold mill wastewater model treatment process is shown in Figure 5.1.5. The plant is in two sections, oil removal and solids removal. A high water-recycling rate is a requirement of this system. The acid pickle line rinses operate on full recycle and the rinse operations of other cold-forming units also operate with high recycling. Refer to Section 4.6.1 for the description of a currently-operating plant using this concept.

The cold-rolling mill coolant blowdown and mist eliminator wastewater is collected and heated in an entry storage tank. The wastewater is pumped in batches to the oil separation tank where acid is added to lower the pH to about one. After mixing and retention the oil floats to the surface as an oil-water mixture and is skimmed from the surface and discharged into the oil neutralization tank. The balance of the wastewater is treated in the solids-removal section of the plant. The acidic oil-water mixture is neutralized, centrifuged and cleaned for recycle to the mill for use as fuel in the plant or as make-up oil for other processes. The water phase from the centrifuge is returned to the oil separation unit and the solids phase is treated in the solids-removal section.

The pickle line and acid regeneration plant scrubber blowdowns, alkaline cleaning rinses, hot coating rinses and scrubber blowdowns are treated in the solids-removal section. These wastewaters are mixed with the effluent from the oil-removal section and neutralized in a two-stage system with lime slurry.

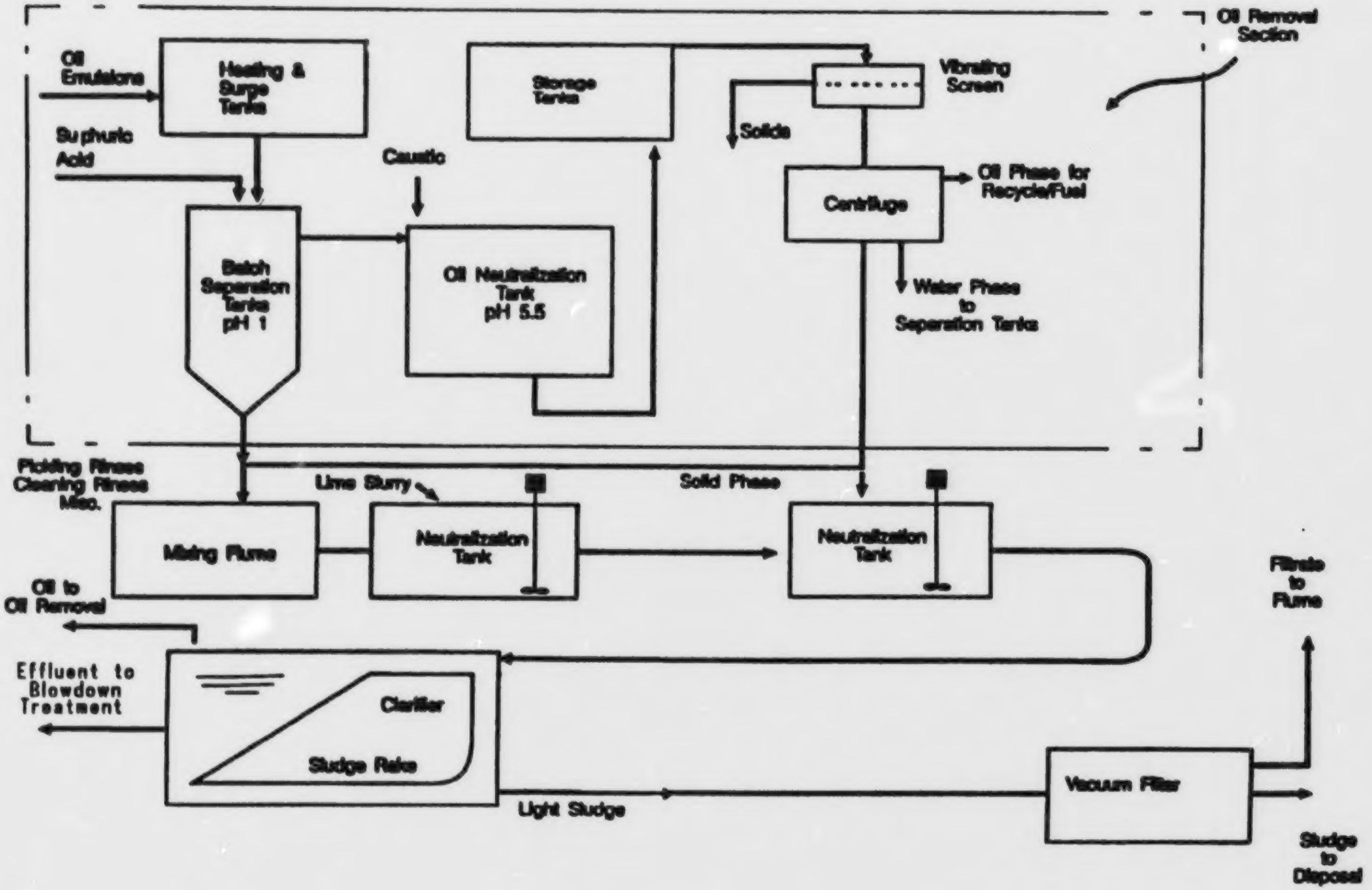

Oil Removal Section
Oil Emulsions
Heating & Surge Tanks
Sulphuric Acid
Storage Tanks
Caustic
Batch Separation Tanks pH 1
Oil Neutralization Tank pH 5.5
Vibrating Screen
Solids
Centrifuge
Oil Phase for Recycle/Fuel
Water Phase to Separation Tanks
Pickling Rinses Cleaning Rinses Misc.
Lime Slurry
Solid Phase
Mixing Flume
Neutralization Tank
Neutralization Tank
Oil to Oil Removal
Effluent to Blowdown Treatment
Clarifier
Sludge Rake
Light Sludge
Vacuum Filter
Filtrate to Flume
Sludge to Disposal

Figure: 5.1.5 Model Cold Mill WasteWater Treatment

Solids-removal is carried out in a clarifier. The effluent is recycled to the extent possible with the balance going to the blowdown treatment plant and the sludge to a thickener. Oil is also skimmed from the clarifier and returned to the oil-removal section. The thickener sludge is de-watered in a vacuum filter or equivalent and the filtrate and thickener overflow are returned to the entry mixing flume.

This process is considered to be BACT. The addition of mixed media filters for the clarifier effluent is considered to be LAER. Acid regeneration is considered to be BACT as is acid pickle line rinse recycle.

5.1.6 Blowdown Treatment Plant

The blowdown treatment plant model process is shown in Figure 5.1.6. The basic description of this process is contained in Section 4.6.2.

One possible change to the process is the replacement of chlorine as an oxidizing agent by other types of oxidizing agents such as hydrogen peroxide to avoid the formation of chlorinated-organic compounds. This change can only be made if the oxidation of cyanides and ammonia can be reduced to the pollutant criteria level. It is considered to be LAER while the balance of the process is considered to be BACT.

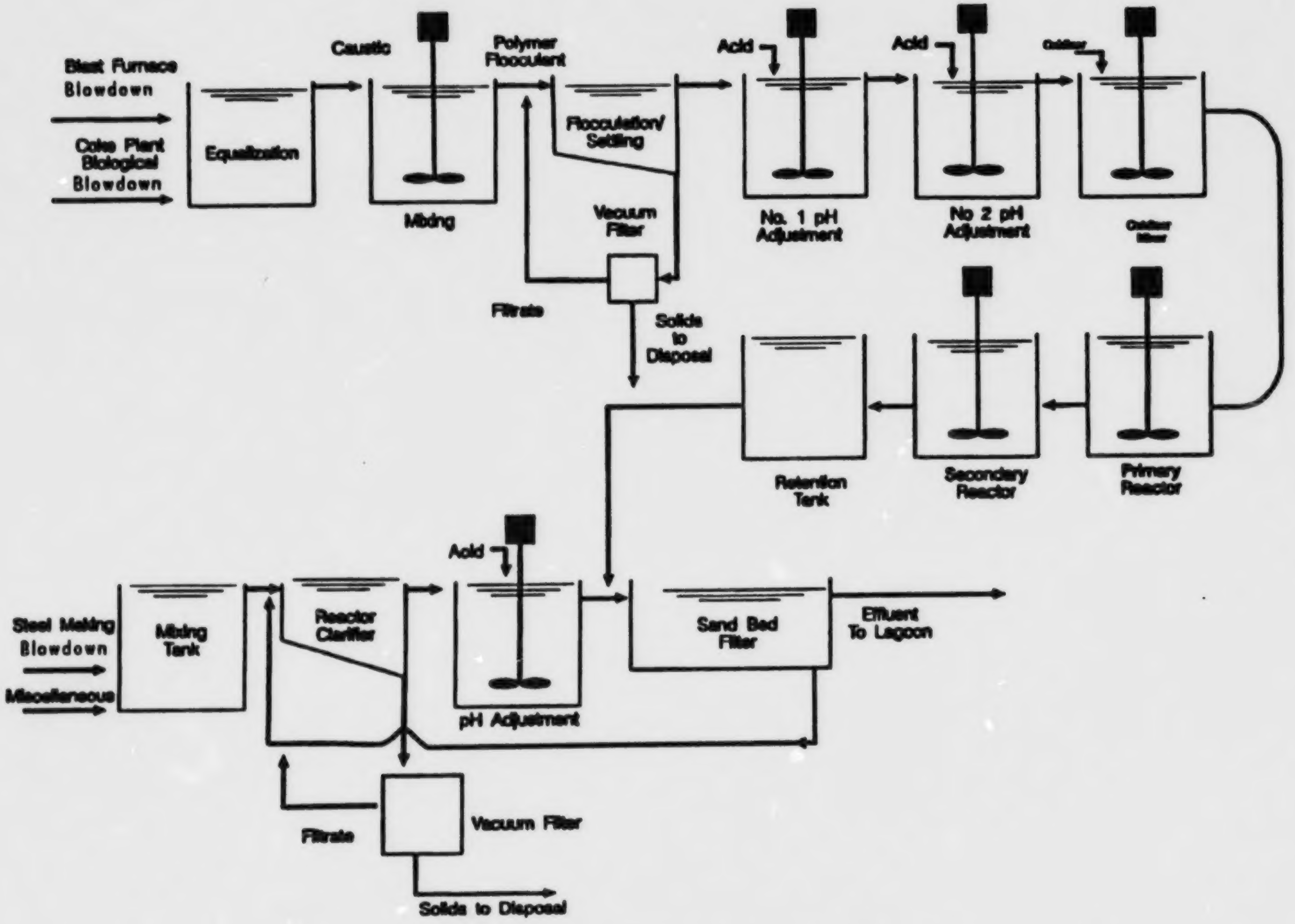

Blast Furnace Blowdown
Coke Plant Biological Blowdown
Equalization
Caustic
Mixing
Polymer Flocculent
Flocculation/ Settling
Vacuum Filter
Filtrate
Solids to Disposal
Acid
No. 1 pH Adjustment
Acid
No 2 pH Adjustment
Oxidizer
Oxidizer Mixer
Primary Reactor
Secondary Reactor
Retention Tank
Steel Making Blowdown
Miscellaneous
Mixing Tank
Reactor Clarifier
Acid
pH Adjustment
Sand Bed Filter
Effluent To Lagoon
Filtrate
Vacuum Filter
Solids to Disposal

Figure: 5.1.6 Model Blowdown Treatment Plant

5.2 Proposed Pollution Control Criteria (by Unit Process)

5.2.0 Introduction

The approach used in the selection of the pollution control criteria was to identify the production processes being adopted by the steel industry that are the most advanced technologically and either are minor polluters or are amenable to pollution control, to identify and quantify the pollution discharged into the environment, and finally to identify the pollution control technologies that achieve the minimum pollutant discharges when applied to the selected production processes.

The pollution control requirements of other countries and published data on pollution control permits, requirements and pollutant discharges were also used in the development process (refer to Appendix A).

A sequential integrated treatment system was developed for the process wastewaters that is based on maximum water re-use and recycling and on treatment for unit production processes with the blowdowns from these treatment units being treated in a blowdown treatment plant prior to discharge into a lagoon. The proposed pollution control criteria have been developed for each major production process based on the background information contained in earlier chapters and the analysis of regulation, permit and discharge data in Appendix C.

BACT has been selected for all processes. In those cases where LAER technologies are available, pollution control criteria have also been developed for LAER as an option. In some cases the technology selected meets both BACT and LAER criteria.

The proposed pollution control criteria are presented in the following sub-sections by process.

5.2.1 Iron Making

5.2.1.1 Raw Material Handling and Storage

Process Wastewater:

Process wastewater from the railcar washing operation should be directed to a sedimentation sump for recovery of coarse material and recycled. If any blowdown occurs, it should be directed to the blowdown treatment plant. There should be zero discharge of process wastewater from all other sources.

Process Run-off Water:

Raw material should be stored on an impervious base with perimeter drainage and the run-off water should be collected in solids-collection sumps. Any discharge from these sumps should be used as make-up for the railcar washing operation.

Air Emissions:

All open-top railcars should be washed before leaving the plant to prevent fugitive air emissions while in transit.

All fixed conveyors, the railcar thaw shed and the railcar dumper should be enclosed with dry-type dust collection at all transfer points.

The proposed pollution control criterion (BACT) for air emissions from the handling of raw materials is: **20 mg/Nm^3**

Fugitive-type Air Emissions:

All storage pile configurations should be designed to minimize particulate emissions due to wind action. Computer modelling of wind action on coal piles should be used in the design of the coal pile configuration. Wind fences should be used at the working face of coal piles.

Movement of coal should be discontinued during periods of high wind. Dust suppressant (non-oil bearing) should be used to minimize particulate emissions from coal storage and coal-handling traffic.

Proposed particulate emission factors for material handling and storage are:

Iron ore:	0.06 kg per tonne of hot metal
Iron pellets:	0.005 kg per tonne of hot metal
Coal:	0.015 kg per tonne of hot metal

Waste Materials:

The proposed pollution control criterion is **zero discharge**. All solid waste should be recycled - coal fines to the coke ovens or blast furnace, iron fines to blast furnace dust recycling or sintering plant.

5.2.1.2 Sintering

Process Wastewater:

Proposed pollution control criterion is zero discharge through the application of dry-type air pollution controls. In those cases where wet-type air pollution controls are necessary (for example, a high content of oil in the feed material from the recycle of oil-bearing sludges), a high water recycling rate would be used. The wastewater would be treated in a sedimentation unit, such as a clarifier, for solids removal and the underflow would be de-watered in a vacuum filter with the filtrate recycled to the sedimentation unit. The blowdown from the system would be discharged to the blowdown treatment plant. Oil and grease would be removed in the sedimentation unit for treatment in a central oil treatment facility. The proposed pollution control guidelines are contained in Table 5.2.1.1. Note that these guidelines are for discharge to the blowdown treatment plant.

TABLE 5.2.1.1 PROPOSED POLLUTION CONTROL GUIDELINES FOR SINTER PLANT WASTEWATER (BACT)

Parameter	Concentration (mg/L)	Process Weight (g/tonne sinter)	
	(1)	(2)	(3)
Model process flow (L/tonne)	400		
pH (units)	6.0 to 8.5		
Total suspended solids	80.0	32.0	16.0
Oil and grease	10.0	4.0	......

(1) Maximum daily concentration.
(2) Maximum for any one day.
(3) Average of daily values for 30 consecutive days.

The pollution control concentration criteria (process weight calculated on flow rate) contained in Table 5.3.1.1 would apply for discharge to a receiving water body.

Process Run-off Water:

Raw material and sinter should be stored on an impervious base with perimeter drainage and sedimentation sumps for solids settling and removal. Any surplus process run-off water should be directed to the blowdown treatment plant.

Air Emissions:

The proposed pollution control criteria for sintering plant air emissions are contained in Table 5.2.1.2.

Solid Waste:

Recommended pollution control criterion is **zero discharge**. All solid waste should be recycled in the plant. Where concentrations of alkalis build up in the collected dust, it may be necessary to dispose of these materials elsewhere. One alternative practised in Japan is to sell this material to cement plants.

TABLE 5.2.1.2 PROPOSED POLLUTION CONTROL CRITERIA FOR SINTER PLANT AIR EMISSIONS (BACT)

Process or operation	Pollutant	Technology	Concentration (mg/Nm^3)	Process Weight * (kg/tonne sinter)
Sinter (1) wind-box	Partic.	Fabric (2) filter	25	0.10
	Manganese	"	0.13	0.0005
	SO_x	Low S fuel	450	1.69
	NO_x	Burner design	350	1.31
Sinter discharge	Partic.	Fabric filter	20	0.05
Sinter cooler	Partic.	Fabric filter	20	0.05
Sinter bldg. fugitives	Partic.	Fabric filter	20	0.003
Sinter crushing and screening	Partic.	Fabric filter	20	0.003
	TOTAL PARTICULATE			0.21

* Process weight is estimated and is not a pollution control criterion.

(1) Opacity not to exceed 20% over a six-minute average.

(2) Wet scrubber may have to be used if oily mill scale is included in the feed, in which case the particulate emission criteria would be 40 mg/Nm^3.

Note that the LAER requirements are:

Sinter wind-box	SO_x	Flue gas Desulphurization	50	0.19
	NO_x	Selective ammonia catalytic reduction	100	0.38

5.2.1.3 Coke Production

Process Wastewater:

The wastewater flows from the various coke plant sources used in the model process are shown in Table 5.2.1.3.

TABLE 5.2.1.3 COKE PLANT WASTEWATER SOURCES AND FLOWS FOR MODEL PROCESS

Wastewater source	Flow (L/tonne coke)
Waste ammonia liquor	130
Final cooler condensate	24
Benzol plant wastewater	80
Miscellaneous sources (leaks, seals, drip legs, test taps, drains)	80
Dilution water to optimize bio-oxidation	160
TOTAL FLOW	474

The proposed pollution control guidelines for coke plant wastewater are shown in Table 5.2.1.4. Note that these guidelines are for discharge of the blowdown to the blowdown treatment plant. The pollution control concentration criteria (process weight calculated on flow rate) contained in Table 5.3.1.1 would apply for discharge to a receiving water body.

TABLE 5.2.1.4 PROPOSED POLLUTION CONTROL GUIDELINES FOR COKE PLANT WASTEWATER (BACT and LAER)

Pollutant	Concentration (mg/L)	Process Weight (g/tonne coke)	
	(1)	(2)	(3)
Model Process Flow (L/tonne)	474		
pH (units)	6.0 to 8.5		
Total suspended solids	15.0	7.1	3.5
Oil and grease	1.0	0.47	....
Ammonia - N	20.0	9.5	4.7
Cyanides (total)	5.0	2.4	1.2
Phenols	0.20	0.095	0.047
Benzene	0.03	0.014	0.007
Naphthalene	0.02	0.009	0.004
Benzo(a)pyrene	0.02	0.009	0.004

(1) Maximum daily concentration.

(2) Maximum for any one day.

(3) Average of daily values for 30 consecutive days.

(4) No increased loading allowed for wet desulphurization systems.

Ammonia still: If a fixed leg ammonia still is used, to avoid the generation of sludge, lime is not to be used for the fixed leg.

Process Area Run-off Water:

All coal, coke and coke breeze should be stored on an impervious base with perimeter drainage directed to a solids settlement sump with the excess water directed to the blowdown treatment plant.

All pumps handling benzene-rich (over 2% benzene) liquids and all storage tanks containing benzene-rich liquids should be located on curbed concrete pads with drains to the process water sewer that goes to the coke oven wastewater treatment plant.

The storage tank pads should be so designed that spills are contained and the spill liquid reclaimed for recycling or treatment.

All other process area run-off water should be directed to the blowdown treatment plant.

Air Emissions:

The proposed pollution control criteria for the air emissions from the by-product coke plant are shown in Table 5.2.1.5.

Specific air pollution control measures for the by-product coke ovens are shown in Table 5.2.1.6.

TABLE 5.2.1.5 PROPOSED BY-PRODUCT COKE PLANT EMISSION CONTROL CRITERIA (EXCLUDING BENZENE) (BACT)

Operation	Pollutant	Technology	Concentration (mg/Nm^3)	Process * Weight (kg/kkg coke)
Coal crushing and handling	Partic.	Fabric filter	20	0.0016
Coal preheating	"	Wet Scrubber	30	0.12
Charging	"	Stage charging	**	0.008
	BSO (1)		**	0.00004
Door leaks	Partic.	Flexible doors, auto-cleaning & maintenance	**	0.030
	BSO (1)		**	0.00004
Lid leaks	Partic.	Operating practices	**	0.020
	BSO (1)		**	0.00015
Off-takes	Partic.	Maintenance, water seals, auto cleaning	**	0.020
	BSO (1)		**	0.0002
Pushing	Partic.	Hood or shed with fabric filter	20	0.020
Wet quenching	"	Multiple baffles	40	0.21
Combustion stack	"	Operating practice & maintenance	35	0.05
	SO_x	Desulphurize coke oven gas	20	0.028
	NO_x	Combustion practice	300	0.42
Coke crushing and screening	Partic.	Fabric filter	20	0.002

(1) BSO (Benzene soluble organics)

* Process weight is estimated and is not a pollution control criterion.

** See Table 5.2.1.4 for control measures. No concentration values are used.

LAER:

Dry quenching	Partic.	Enclosed pushing & wet scrubber	40	0.10
Combustion stack	NO_x	Selective ammonia catalytic reduction	90	0.13

TABLE 5.2.1.6 BY-PRODUCT COKE OVENS AIR POLLUTION CONTROL MEASURES (LAER)

Operation		Air Pollution Control Measure
Charging		Visible emissions not to exceed an aggregate time of 55 seconds for any five consecutive charges. At least one set of observations to be taken each day.
Door leaks		No more than five percent of observed doors to be leaking at any one time (excluding last oven charged). At least one set of observations to be taken each day.
Lid leaks		No more than one percent of observed lids to be leaking at any one time. At least one set of observations to be taken each day.
Off-take piping		No more than four percent of off-takes to be leaking at any one time (excluding three ovens). At least one set of observations to be taken each day.
Collection main(s)		No visible emissions.
Pushing		Opacity is not to exceed 20 percent except for the quench car travel for which the opacity is not to exceed 10 percent.
Combustion stack		Opacity is not to exceed 20 percent except for a maximum of three minutes in 60 minutes when opacity is not to exceed 40 percent.
Coke oven gas		The total sulphur content of the coke oven gas is not to exceed 100 mg/Nm^3.
Wet quenching	*	Quench tower to be designed with multiple rows of baffles, mist suppression, facility for emission testing and clean water make-up.
Coke oven gas	*	No discharge of coke oven gas to the atmosphere; coke oven gas flares of approved design to be used.
Note:	*	BACT

Specific benzene emission control measures for the coke oven by-product plant operations are shown in Table 5.2.1.7. The estimated residual benzene emissions are shown in Table 5.2.1.8.

TABLE 5.2.1.7 SPECIFIC BENZENE EMISSION CONTROL MEASURES (LAER)

Source or operation	Measure
Light oil storage tanks, flushing liquor circulation tank, light oil condenser, light oil decanter, wash oil decanter or wash oil tank.	Inert gas blanketing with gases ducted to a benzene recovery or destruction system. *
Light oil truck loading station.	Vapour balance system.
Light oil, wash oil pump sumps.	Sump must be enclosed with provision for venting to benzene recovery or destruction system. *
Pumps, exhauster and booster.	Equipped with double seals to prevent any benzene leak.
Process or equipment benzene leaks.	Standard operating procedure to identify and eliminate benzene leaks.
Benzene vapour destruction *	Thermal destruction at a temperature in excess of 700°C in a smokeless flare or direct-flame incinerator with a destruction efficiency in excess of 98 percent.

TABLE 5.2.1.8 RESIDUAL BENZENE EMISSIONS AFTER APPLICATION OF SPECIFIC CONTROL MEASURES FOR BY-PRODUCT COKE OVENS AND BY-PRODUCT PLANT (LAER)

Source	g/tonne coke
Final-cooler cooling tower	0
Tar-intercepting sump	1.9
Tar decanter	1.5
Light oil condenser and decanter vent	1.8
Tar de-watering	0.4
Light oil sump	0.24
Tar storage	0.24
Pump seals	0.15
Flushing liquor circulation tank	0.18
Excess ammonia liquor tank	0.18
Benzene storage	0.12
Valves	0
Wash oil decanter and circulation tank	0.18
Pressure relief devices	0
Exhausters	0
Sample connections and open ended lines	0
Total	7

Solid Waste:

A number of by-products and solid wastes are generated in by-product coke ovens. The disposal of these materials is outlined below.

Coke breeze should be recycled to coke ovens or sinter plant or sold as a by-product.

Tar by-product should be recycled in-plant or sold as a by-product. If the tar is recycled in the plant, it may require some processing (e.g. for use as fuel).

Particulate collected by air pollution control equipment should be recycled wherever feasible.

The sludge generated by the biological treatment system can be recycled to the coke ovens.

Tar decanter tank sludge can be circulated through a solvent grinding pump and then sprayed onto the coal prior to charging into the ovens.

Caustic soda should be used in the ammonia still to eliminate ammonia still sludge although this will increase the concentration of dissolved solids in the wastewater. If lime is used, the sludge will have to be disposed to a landfill site.

Elemental sulphur, anhydrous ammonia, ammonium sulphate and sulphuric acid are other potential by-products. These are all saleable products although some, such as ammonium sulphate, may be difficult to sell.

See Section 5.3 for landfill or off-site disposal for all of the above solid wastes.

5.2.1.4 Iron Production (Blast Furnace)

Wastewater:

The proposed pollution control guidelines for the blast furnace wastewater are shown in Table 5.2.1.9. Note that these guidelines are for discharge to the blowdown treatment plant. The pollution control concentration criteria (process weight calculated on flow rate) contained in Table 5.3.1.1 would apply for discharge to a receiving water body.

TABLE 5.2.1.9 PROPOSED POLLUTION CONTROL GUIDELINES FOR BLAST FURNACE WASTEWATER (BACT)

Pollutant	Concentration (mg/L)	Process Weight (g/tonne iron)	
	(1)	(2)	(3)
Model Process Flow (L/tonne)	292		
pH (units)	6.0 to 8.5		
Total suspended solids	60.0	17.5	8.7
Oil and grease	1.0	0.29	....
Ammonia - N	10.0	2.90	1.45
Cyanides (total)	2.0	0.60	0.30
Phenols (4AAP)	0.15	0.043	0.021
Lead (total)	0.75	0.22	0.11
Zinc (total)	0.90	0.26	0.13

(1)	Maximum daily concentration.
(2)	Maximum for any one day.
(2)	Average of daily values for 30 consecutive days.

Air Emissions

The proposed pollution control criteria for the air emissions from the blast furnace are shown in Table 5.2.1.10.

Specific air pollution control measures for the blast furnace are shown in Table 5.2.1.11.

TABLE 5.2.1.10 PROPOSED POLLUTION CONTROL CRITERIA FOR EMISSIONS FROM THE BLAST FURNACE (BACT)

Operation	Pollutant	Technology	Concentration (mg/Nm^3)	Process * Weight (kg/kkg iron)
Raw materials handling	Particulate	Fabric filter	20	0.002
Cast house	"	Fabric filter	20	0.012
Slag pouring or granulating	Particulate	Hood & wet scrubber	30	0.004
Slag crushing and screening	"	see Section 5.3.3		
Hot metal desulphurization	"	Fabric filter	20	0.003
Combustion stack (stoves)	"	Use of clean gas & maintenance	10	0.015
	SO_x (1)		...	.....
	NO_x	Combustion practise	80	0.120
	Dioxins (2)		0.5×10^{-6}	
Ladle de-kishing	Particulate	Fabric filter	20	0.003

* Process weight is estimated and is not a pollution control criterion.

(1) SO_x emissions are very low due to the low sulphur content of the blast furnace gas used for combustion. No pollution control criterion has been set.

(2) Toxic equivalent factor (TEF) NATO Protocol

TABLE 5.2.1.11 BLAST FURNACE AIR POLLUTION CONTROL MEASURES (BACT)

Operation	Air Pollution Control Measure
Cast house	Tapping operation, iron and slag runners hooded and evacuated to control equipment; runner length minimized; hood iron pouring into ladle. Opacity of cast house roof monitors not to exceed 15% over a six minute period.
Slag quenching	Granulate or pelletize slag in enclosed facility with gas cleaning or air cool in slag pit until slag is below TRS formation temperature, then quench with recycled quench water and make-up from blast furnace gas cleaning water. Slag pit to have impervious lining with sumps to retain excess quenching water.
Ladle de-kishing	Ladle de-kishing operation to be hooded and gases cleaned. De-kishing of ladles to be scheduled to minimize kish emissions from ladles.
Blast furnace slips	Should be minimized and reported.

Solid Waste:

Blast furnace slag may be pelletized or granulated for use as a construction lightweight aggregate. The handling and processing of quenched slag is usually carried out by an outside party and is covered in Section 5.3.3.

Iron-bearing material collected by the blast furnace gas-cleaning system should be recycled wherever feasible. In some cases the material may be recycled through a sinter plant. An emerging technology is cold bonding briquetting for use as part of the blast furnace burden. If this material is high in zinc or lead, further processing may be necessary before recycling to the blast furnace.

Particulate from air pollution control equipment should be recycled wherever feasible. Some of this material, such as kish, may be combined with the gas-cleaning material.

Other solid wastes include refractories and packaging materials.

Refer to Section 5.3.3 for on-site or off-site storage and disposal of all of the above materials.

5.2.2 Steel Making

5.2.2.1 Process Wastewater

The proposed pollution control guidelines for steel-making wastewater are shown in Table 5.2.2.1. Note that these guidelines are for discharge to the blowdown treatment plant. The pollution control concentration criteria (process weight calculated on flow rate) contained in Table 5.3.1.1 apply for discharge to a receiving water body.

TABLE 5.2.2.1 PROPOSED POLLUTION CONTROL GUIDELINES FOR STEEL-MAKING WASTEWATER (BACT)

Operation and Pollutant	Concentration (mg/L)	Process Weight (g/tonne steel)	
	(1)	(2)	(3)
(Includes vacuum degassing and continuous casting)			
Model process flow (L/tonne)	334		
pH (units)	6.0 to 8.5		
Basic Oxygen Furnace			
Total suspended solids	60.0	20.0	10.0
Lead (total)	0.90	0.30	0.15
Zinc (total)	1.25	0.42	0.21
Electric furnace	zero discharge (LAER)		
Ladle metallurgy	zero discharge (LAER)		

(1) Maximum daily concentration.
(2) Maximum for any one day.
(2) Average of daily values for 30 consecutive days.

Air Emissions

The proposed pollution control criteria for the air emissions from steel making are shown in Table 5.2.2.2. Control measures are shown in Table 5.2.2.3.

TABLE 5.2.2.2 PROPOSED POLLUTION CONTROL CRITERIA FOR EMISSIONS FROM STEEL MAKING (BACT)

Operation	Pollutant	Technology	Concentration (mg/Nm^3)	Process Weight * (kg/kkg steel)
Raw materials handling	Partic.	Fabric filter	20	0.0005
Basic oxygen furnace				
Melting & refining	Partic.	High energy wet scrubber	35	0.0070
	Copper		0.04	
	Cadmium	"	0.0008	
	Manganese	"	0.8	
	Zinc	"	1.6	
	Dioxins (1)	"	$0.5x10^{-6}$	
Charging	Partic.	Fabric filter	20	0.0003
Tapping	Partic.	Fabric filter	20	0.0009
Slagging	Partic.	Fabric filter	20	0.0007
Hot metal transfer	Partic.	Fabric filter	20	0.0010
Ladle metallurgy (Elect. fce.)	Partic.	Fabric filter	20	0.0040 (2)
Slag crushing and screening		See Section 5.3.3		

LAER: Basic oxygen furnace carbon monoxide recovered for fuel.

* Process weight is estimated and is not a pollution control criterion.

(1) Toxic equivalent factor(TEF) NATO Protocol

(2) Process weight is kg/tonne of steel processed in the electric furnace.

TABLE 5.2.2.2 (cont.) PROPOSED POLLUTION CONTROL CRITERIA FOR EMISSIONS FROM STEEL MAKING (BACT)

Operation	Pollutant	Technology	Concentration (mg/Nm^3)	Process Weight * (kg/kkg steel)
Electric arc furnace				
Melting, refining charging, tapping, & slagging	Partic.	Direct evacuation, fabric filter with auxiliary or canopy hood and fabric filter	20	0.0090
	Copper		0.01	
	Cadmium		0.0004	
	Manganese		2.0	
	Zinc		2.6	
	Dioxins (1)		0.5×10^{-6}	
Slag crushing and screening	See Section 5.3.3			

LAER	Electric furnace emission limit	12 mg/Nm^3

* Process weight is estimated and is not a pollution control criterion.

TABLE 5.2.2.3 EMISSION CONTROL MEASURES FOR STEEL MAKING

Operation	Control Measure
Basic oxygen furnace:	
Primary stack and roof monitor	Opacity not to exceed 10% over a six-minute period except 20% over a six-minute period once each cycle.
Electric Furnace:	
Primary stack	Opacity not to exceed 5% over a six-minute period.
Roof monitor	Opacity not to exceed 10% over a six-minute period.

Solid Waste:

Slag:

The handling and processing of slag is usually carried out by an carried out by an outside party and is covered in Section 5.3.3.

Basic oxygen slag should be processed for steel recovery, partial recycle to blast furnace and sale of the balance as a by-product. Electric furnace slag should be processed for steel recovery and resale as a by-product. The crushed slag is often used as a construction aggregate. Some basic oxygen furnace slag is used as aggregate in asphalt for road paving. This application is growing since the slag is harder than conventional aggregate and provides a better-wearing surface.

Collected dust:

Basic oxygen and electric furnace dust should be recycled where feasible. Note that electric furnace dust often has high zinc concentrations and must be processed in a Waelz kiln or similar process with zinc oxide recovery before the dust is suitable for recycling.

Dust collected from the material-handling operations is sometimes recycled in the plant or sold as a raw material for cement production.

Other solid waste includes refractories and packaging materials.

Refer to Section 5.3 for on-site or off-site storage or disposal of all of the above materials.

5.2.3 Hot Forming

5.2.3.1 Process Wastewater

The proposed pollution control guidelines for hot-forming wastewater are shown in Table 5.2.3.1. Note that these guidelines are for the blowdown from the hot-forming treatment plant to be discharged to steel making as make-up for the gas-cleaning system with the balance being discharged to the blowdown treatment plant. The pollution control concentration criteria (process weight calculated on flow rate) contained in Table 5.3.1.1 apply for discharge to a receiving water body.

TABLE 5.2.3.1 PROPOSED POLLUTION CONTROL GUIDELINES FOR HOT-FORMING WASTEWATER BACT)

Operation and Pollutant	Concentration (mg/L)	Process Weight (g/tonne steel)	
	(1)	(2)	(3)
Model process flow (L/tonne)	550		
pH (units)	6.0 to 8.5		
Hot rolling including scarfing			
Total suspended solids	40.0	22.0	11.0
Oil and grease	5.0	2.8	....
Lead (total)	0.040	0.02	0.01
Zinc (total)	0.050	0.03	0.02

(1) Maximum daily concentration.

(2) Maximum for any one day.

(2) Average of daily values for 30 consecutive days.

Air Emissions

The proposed pollution control criteria for the air emissions from hot forming are shown in Table 5.2.3.2.

TABLE 5.2.3.2 PROPOSED POLLUTION CONTROL CRITERIA FOR HOT-FORMING EMISSIONS (BACT)

Operation	Pollutant	Technology	Concentration (mg/Nm^3)	Process Weight* (kg/kkg steel)
Reheating furnace	Part.	Burner design, fuel selection	10	0.004
	SO_x	Fuel selection	20	0.008
	NO_x	Fuel selection, burner design	100	0.040
Scarfer	Part.	Wet ESP	25	0.012
LAER:				
Reheating furnaces	NO_x	Selective ammonia catalytic reduction	30	0.012

* Process weight is estimated and is not a pollution control criterion.

Solid Waste:

Mill scale should be recycled as feasible. Oily mill scale presents recycling and disposal problems but oil content can be reduced by using air/oil mist lubrication systems in the rolling mills rather than grease. Dust and sludge from the pollution control units are to be recycled where feasible. Other solid wastes include refractories, oil and grease, solvents and paint cans.

Refer to Section 5.3 for on-site or off-site storage or disposal of all of the above materials.

5.2.4 Cold Forming

5.2.4.1 Process Wastewater

The proposed pollution control guidelines for cold-forming wastewater are shown in Table 5.2.3.1. Note that these guidelines are for discharge to the blowdown treatment plant. The pollution control concentration criteria (process weight calculated on flow rate) contained in Table 5.3.1.1 apply for discharge to a receiving water body.

5.2.4.1.1 By Unit Process

TABLE 5.2.4.1 PROPOSED POLLUTION CONTROL GUIDELINES FOR COLD-FORMING WASTEWATER (BACT)

Operation and Pollutant	Concentration (mg/L)	Process Weight (g/tonne steel)	
	(1)	(2)	(3)
pH (units)	6.0 to 8.5		
(i) Cold rolling			
Model process flow (L/tonne)	42		
Total suspended solids	60.0	2.5	1.2
Oil and grease	10.0	0.42	0.21
Lead (total)	0.45	0.019	0.009
Zinc (total)	0.30	0.013	0.006
(ii) Acid Pickling (including fume scrubber and acid regeneration)			
Model process flow (L/tonne)	60		
Total suspended solids	70.0	4.2	2.1
Oil and grease	5.0	0.30	0.15
Lead (total)	0.45	0.027	0.014
Zinc (total)	0.30	0.018	0.009

TABLE 5.2.4.1 (cont.) **PROPOSED POLLUTION CONTROL GUIDELINES FOR COLD-FORMING WASTEWATER (BACT)**

Operation and Pollutant	Concentration (mg/L)	Process Weight (g/tonne steel)	
	(1)	(2)	(3)
(iii) Alkaline Cleaning			
Model process flow (L/tonne)	209		
Total suspended solids	60.0	12.5	6.2
Oil and grease	10.0	2.1	1.0
(ii) Hot Coating (including fume scrubber)			
Model process flow (L/tonne)	600		
Total suspended solids	70.0	42.0	21.0
Oil and grease	5.0	3.0	...
Chromium (total)	0.10	0.06	0.03
Lead (total)	0.45	0.27	0.13
Zinc (total)	0.30	0.18	0.09

(1)	Maximum daily concentration.
(2)	Maximum for any one day.
(2)	Average of daily values for 30 consecutive days.

5.2.4.1.2 Cold-Forming Central Wastewater Treatment Plant

The proposed pollution control guidelines for cold-forming wastewater for a central wastewater treatment plant are shown in Table 5.2.4.1.2. This process is considered to be BACT since the total flow and pollutant loading is lower than the sum of the individual processes in Section 5.2.4.1.1. Note that these guidelines are for discharge to the blowdown treatment plant. The pollution control concentration criteria (process weight calculated on flow rate) contained in Table 5.3.1.1 apply for discharge to a receiving water body.

TABLE 5.2.4.2 PROPOSED POLLUTION CONTROL GUIDELINES FOR COLD-FORMING WASTEWATER CENTRAL TREATMENT (BACT)

Operation and Pollutant	Concentration (mg/L)	Process Weight (g/tonne steel)	
	(1)	(2)	(3)
Cold rolling, Acid Pickling including acid regeneration, Alkaline Cleaning, Hot Coating, Fume Scrubbers and Cold-Rolling Mist Eliminators.			
Model Process Flow (L/tonne)	350		
pH (units)	6.0 to 8.5		
Total suspended solids	60.0	21.0	10.5
Oil and grease	5.0	1.75	....
Chromium (total)	0.05	0.018	0.009
Lead (total)	0.10	0.035	0.017
Zinc (total)	0.20	0.070	0.035

(Does not include Electrolytic coating)

(1) Maximum daily concentration.

(2) Maximum for any one day.

(2) Average of daily values for 30 consecutive days.

5.2.4.2 Air Emissions

The proposed pollution control criteria for the air emissions from cold forming are shown in Table 5.2.4.2.

TABLE 5.2.4.3 PROPOSED POLLUTION CONTROL CRITERIA FOR COLD-FORMING EMISSIONS (BACT)

Operation	Pollutant	Technology	Concentration (mg/Nm^3)	Process Weight (kg/kkg steel) *
Cold rolling	Oil mist	Mist eliminator	15	0.005
Acid pickling	Particulate	Packed bed scrubber	20	0.002
	HCl fumes		5	0.0005
Acid regeneration	Particulate	Packed bed scrubber	20	0.0005
	HCl fumes		5	0.0001
Annealing furnaces	Particulate	Burner design, fuel selection	10	0.001
	SO_x	Fuel selection	10	0.001
	NO_x	Fuel selection, burner design	100	0.012
Hot coating	Particulate	Packed bed scrubber	20	0.001
LAER:				
Annealing	NO_x	Selective ammonia catalytic reduction	40	0.005

* Process weight is estimated and is not a pollution control criterion.

Solid Waste:

Iron oxide material from acid regeneration should be recycled or sold. Dust and sludge from pollution control facilities should be recycled where feasible. Other solid wastes include solvents, refractories, oil and grease. Refer to Section 5.3 for on-site or off-site storage or disposal of these materials.

5.2.5 Utilities

5.2.5.1 Wastewater

The only wastewater streams are the blowdown from the boiler feedwater treatment plant, oxygen plant cooling water and air compressor cooling water. These should be directed to the blowdown treatment plant. The pollution control concentration criteria contained in Table 5.3.1.1 apply for discharge to a receiving water body.

5.2.5.2 Air Emissions

The proposed pollution control criteria for the air emissions from the central boiler house are shown in Table 5.2.5.1.

TABLE 5.2.5.1 PROPOSED POLLUTION CONTROL CRITERIA FOR CENTRAL BOILER HOUSE EMISSIONS (BACT)

Operation	Pollutant	Technology	Concentration (mg/Nm^3)	Process Weight * (kg/kkg steel)
Combustion	Particulate	Fuel selection	40	0.013
	SO_x	Fuel selection	10	0.003
	NO_x	Fuel selection, burner design	270	0.08

Note: Based on the use of approximately 40 percent blast furnace gas and balance de-sulphurized coke oven gas.

* Process weight is estimated and is not a pollution control criterion.

5.2.5.3 Solid Waste

The solid wastes include the sludge from the boiler feed- water system, refractories and packaging materials. Refer to Section 5.3 for on-site or off-site storage or disposal of these materials.

5.2.6 Blowdown Treatment Plant

5.2.6.1 Introduction

The blowdowns from the various unit process wastewater treatment plants are treated in this facility. The plant is composed of two sections:

i) Chemical section treating the blowdowns from the blast furnace and coke oven treatment plants and the process run-off from the by-product plant that contains benzene and other organic compounds.

ii) Mechanical section treating the steel-making blowdown, that part of the hot mill blowdown that is not cascaded to the steel-making system as make-up, the cold-mill blowdown, the effluent from the chemical section plus the blowdowns from cooling towers and boiler feedwater system and miscellaneous other minor wastewater streams.

Process run-off wastewater, excluding coke oven by-product plant, is collected in a storage facility and discharged to the mechanical section at an even flow rate.

5.2.6.2 Process Wastewater

The proposed blowdown treatment plant model process is described in Sub-section 5.1.6.

The model process flow is based on the summation of the blowdowns from the unit process treatment plants described in Section 5.1. These flows, based on the steel plant model process in Appendix B-2, are shown in Table 5.2.6.1.

TABLE 5.2.6.1 BLOWDOWN FLOWS FROM UNIT PROCESS WASTEWATER TREATMENT PLANTS TO BLOWDOWN TREATMENT

Unit process treatment plant	Flow (L/tonne crude steel)
By-product coke plant	120
Blast furnace	230
Steel making	340
Hot forming (balance that is not cascaded to steel making)	280
Miscellaneous sources (1) (estimated 25%)	240
TOTAL (2) (3)	1,210

(1) Includes blowdowns from cooling towers, boiler feedwater system, coke plant sumps and pump and tank pads and miscellaneous other sources.

(2) Does not include the process run-off water that is site-specific and the quantity varies with the area precipitation and plant layout.

(3) Does not include cold-forming blowdown which should be added based on the specific cold-forming production processes and capacities that are included in the plant.

The proposed pollution control guidelines for the blowdown treatment plant are shown in Table 5.2.6.2 for the blowdowns included in Table 5.2.6.1, which excludes the process run-off and cold-forming blowdown. If any cold-forming facilities are included in the steel plant, the blowdown from the central cold-mill wastewater treatment plant would be added.

The blowdown treatment plant discharges into a lagoon where chemical reactions are completed, some additional biological activities occur and there is sufficient retention capacity to ensure that wastewater equalization is completed prior to discharge to the receiving water body. The proposed pollution control criteria for the wastewater discharge to the receiving water body are shown in Table 5.3.1.1.

TABLE 5.2.6.2 PROPOSED POLLUTION CONTROL GUIDELINES FOR BLOWDOWN TREATMENT PLANT - PROCESS WASTEWATER (1)

Pollutant	Concentration (mg/L)	Process Weight (g/tonne of crude steel)	
	Maximum Daily	Day (2)	30 day (3)
Model process flow (L/tonne crude steel)		1,210	
pH (units)	6.0 to 8.5		
Total suspended solids	10.0	12.1	6.0
Oil and grease	1.5	1.8	....
Ammonia - N	1.0	1.2	0.60
Cyanides (total)	0.08	0.97	0.05
Phenols	0.005	0.006	0.003
Benzene	0.002	0.0024	0.0012
Naphthalene	0.002	0.0024	0.0012
Benzo(a)pyrene	0.0006	0.0007	0.0003
Total residual chlorine	0.015	0.018	0.009
Chromium (total)	0.05	0.060	0.030
Lead (total)	0.15	0.18	0.09
Zinc (total)	0.18	0.22	0.11

(1) Does not include blowdown from cold forming or process run-off water

(2) Maximum for one day

(3) Average for 30 consecutive days

Air Emissions:

There are no air emissions requiring control.

Solid Waste:

The only solid waste is the sludge from the water treatment process. Refer to Section 5.3.3 for on-site or off-site storage or disposal for this sludge.

5.3 Proposed Pollution Control Criteria (for Plant Discharge)

5.3 Introduction

The proposed pollution control criteria at the plant level are based on the background information in earlier sections, the unit process proposed models for wastewater treatment in Section 5.1 and the unit process pollution control criteria developed in Section 5.2.

The basic approach for the water treatment pollution control criteria was to develop unit treatment processes for each major production process and for the blowdown from these unit processes to be treated in the blowdown treatment unit. The effluent from this blowdown treatment unit would discharge into a lagoon, which in turn would discharge into the receiving water body. This approach is based on currently available technology and was selected to minimize the discharge of pollutants, maximize water recycle and minimize the water discharge. It also minimizes or eliminates the potential excessive pollutant discharges since each process unit will at least partially control spills or malfunction discharges with a further stage of treatment before the effluent is discharged into the lagoon.

The process run-off water is also directed to the blowdown treatment plant where it is treated before discharge into the lagoon.

The water run-off resulting from precipitation (precipitation run-off) on those areas of the plant that are not used for production facilities, material storage, roadways or parking lots is collected in a separate lagoon. This water is tested,prior to discharge, to determine whether concentrations of any pollutants exceed the pollution criteria contained in Table 5.3.1.1. If an excessive concentration of any pollutant occurs, measures are to be taken to identify the source and prevent recurrence.

Air emissions are controlled at source.

The storage and disposal of waste materials must be in accordance with the Province of British Columbia's Special Waste Regulation outlined in Section 5.3.3.

The total wastewater allowable pollutant discharges are shown in Table 5.3.1.1. These discharges are based on the model plant outlined in Appendix B and on a modular plant size of three million tonnes of crude steel production per year. The discharge of pollutants for larger-sized plants is based on the pollution control criteria of the three-million-tonne-per-year-capacity modular plant and decreases on a kg per tonne of steel basis for the additional production above three million tonnes per year.

The air pollution criteria are shown in Tables 5.3.2.1 - 4 by pollutant type. The process weight is estimated and is not a pollution control criterion but is included as an indicator. The total air emission pollutant discharge from the plant should be calculated according to the design and test data and pro-rated on a kg per tonne basis for capacities above three million tonnes per year, similar to the wastewater pollutants discussed above.

The selection of specific pollutants for which pollution control criteria have been developed has been based on the pollutants normally encountered in a steel plant and on the relationship with other pollutants generated in the various processes. Thus, for example, the control of benzene and PAH from the coke ovens also ensures that other hydrocarbon compounds are controlled and do not require specific emission limits. Similarly in the wastewater parameters some pollutants can be used as surrogates for other pollutants or for classes of pollutants. The stringent discharge limits for various critical hydrocarbons such as benzene, naphthalene and benzo(a)pyrene act as surrogates for other parameters (e.g., total organic carbon).

5.3.1 Wastewater Discharge

5.3.1.1 Introduction

The wastewater proposed pollution control criteria for the plant is based on a sequential integration treatment system approach as shown in Figure 5.3.1. The blowdowns from the unit process wastewater treatment plants are directed to the blowdown treatment plant as shown in the above figure.

The unit model processes and proposed pollutant control criteria are located as follows:

i) Iron making:

Unit process wastewater treatment plant description:

Coke Production	Section 5.1.1
Blast furnace	Section 5.1.2

Unit process model flowsheets:

Coke production	Figure 5.1.1
Blast furnace	Figure 5.1.2

Proposed pollution control criteria:

Coke production	Table 5.2.1.2
Blast furnace	Table 5.2.1.7

ii) Steel making:

Unit process wastewater treatment plant description:	Section 5.1.3
Unit process model flowsheet:	Figure 5.1.3
Proposed pollution control criteria:	Table 5.2.2.1

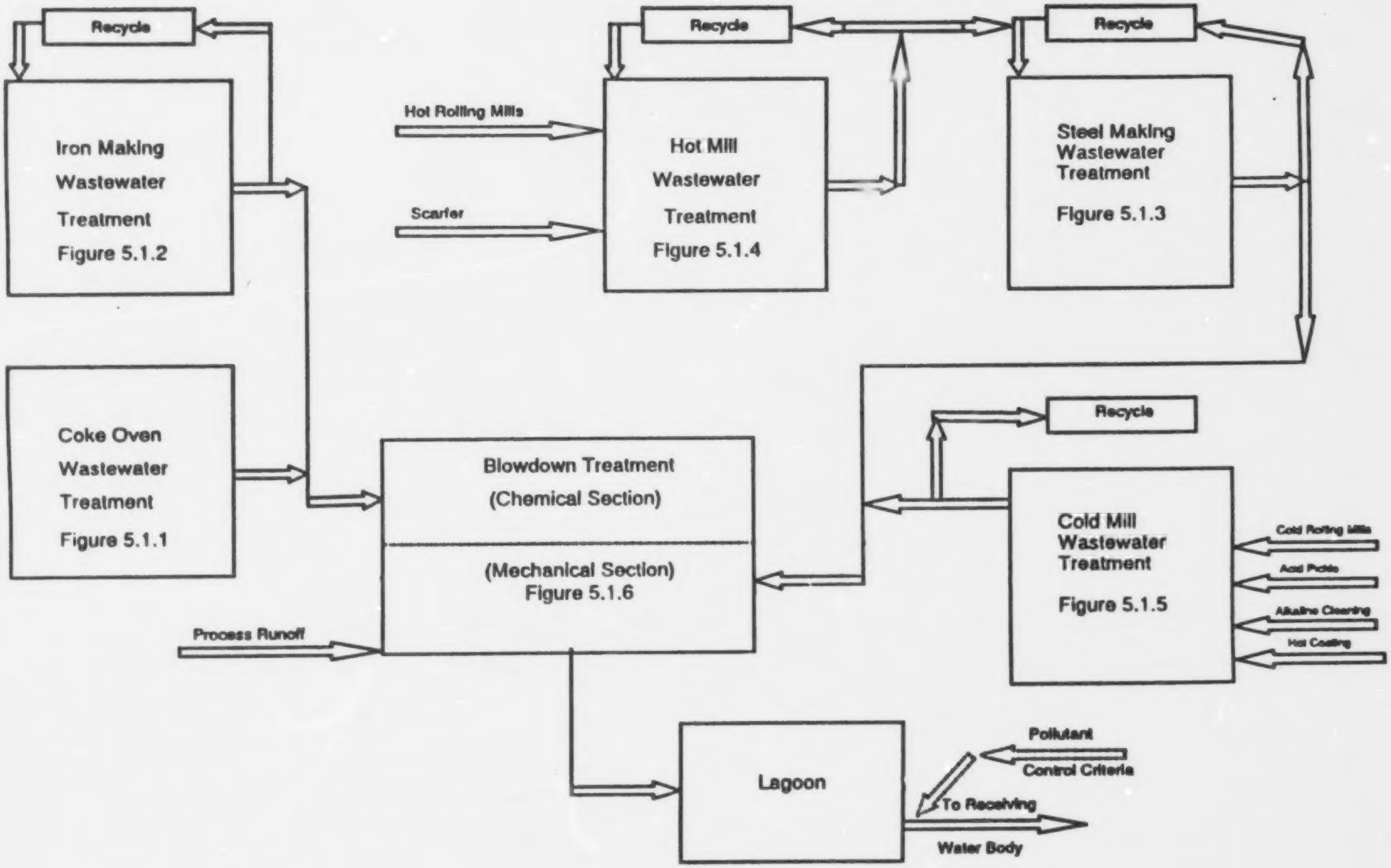

Recycle
Iron Making
Wastewater
Treatment
Figure 5.1.2
Recycle
Hot Rolling Mills
Scarfer
Hot Mill
Wastewater
Treatment
Figure 5.1.4
Recycle
Steel Making
Wastewater
Treatment
Figure 5.1.3
Coke Oven
Wastewater
Treatment
Figure 5.1.1
Blowdown Treatment
(Chemical Section)
(Mechanical Section)
Figure 5.1.6
Process Runoff
Recycle
Cold Mill
Wastewater
Treatment
Figure 5.1.5
Cold Rolling Mills
Acid Pickle
Alkaline Cleaning
Hot Coating
Lagoon
Pollutant
Control Criteria
To Receiving
Water Body

Figure: 5.3.1: Sequential Integrated Wastewater Treatment System

iii) Hot forming:

Unit process wastewater treatment plant description: Section 5.1.4
Unit process model flowsheet: Figure 5.1.4
Proposed pollution control criteria: Table 5.2.3.1

iv) Cold forming:

Unit process wastewater treatment plant description: Section 5.1.5
Unit process model flowsheet: Figure 5.1.5

Proposed pollution control criteria: Table 5.2.4.2

v) Blowdown treatment:

Unit process wastewater treatment plant description: Section 5.1.6
Unit process model flowsheet: Figure 5.1.6

Proposed pollution control criteria: Table 5.2.6.1
Table 5.2.6.2

5.3.1.2 Process and Process Run-off Wastewater

In the model treatment process there is only one discharge of process and process run-off wastewater from the plant - that from the lagoon to the receiving water body. The model treatment process is based on the lagoon's having a retention time of ten days minimum. The proposed pollution control criteria for this final **discharge to both fresh water and the marine environment** are shown in Table 5.3.1.1 for the conventional pollutants (Group 1) and in Tables 5.3.1.2 and 5.3.1.3 for other pollutants (Group 2). These final discharge pollution control criteria are considered to be BACT even though elements of LAER have been incorporated into the approach and the selection of the final pollution control criteria.

TABLE 5.3.1.1 **PROPOSED POLLUTION CONTROL CRITERIA FOR WASTEWATER DISCHARGE TO THE RECEIVING WATER BODY FOR GROUP 1 POLLUTANTS (1)**

Pollutant	Concentration (mg/L)	Process Weight (g/tonne of crude steel) (2)	
	Maximum Daily	Day (3)	30 day (4)
Model process flow (L/tonne crude steel)		1,210	
pH (units)		6.0 to 8.5	
Total suspended solids	10.0	12.1	6.0
Oil and grease	1.5	1.8	....
Ammonia - N	1.0	1.2	0.6
Cyanides (total)	0.08	0.097	0.05
Phenols	0.005	0.0060	0.0030
Benzene	0.002	0.0024	0.0012
Naphthalene	0.002	0.0024	0.0012
Benzo(a)pyrene	0.0006	0.0007	0.0003
Total residual chlorine	0.015	0.018	0.009
Chromium (total)	0.05	0.060	0.030
Lead (total)	0.15	0.18	0.090
Zinc (total)	0.18	0.22	0.11

Toxicity:	The wastewater is to meet the following toxicity criteria:
Fish Toxicity Tests	Flow-through bioassay to meet 96-h LC_{50} at 100 percent (i.e. 96-hour fish bioassay measure be non-toxic at 100 percent strength wastewater)
	Daphnia Magna acute lethality toxicity static bioassay to meet 96-h LC50 at 100 percent

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(1) Model process flow and process weight of pollutants to be added for any cold-mill units that are included in plant.

(2) Pollutant weight in process run-off water to be added as appropriate.

(3) Maximum for one day

(4) Average for 30 consecutive days

TABLE 5.3.1.2 PROPOSED POLLUTION CONTROL CRITERIA FOR WASTEWATER DISCHARGE TO THE RECEIVING WATER BODY FOR GROUP 2A POLLUTANTS

Pollutant	Concentration (ug/L) Maximum Daily	Process Weight (g/tonne crude steel) 30-day average
Acenaphthene	0.7	0.00050
Acenaphthylene	0.4	0.00028
Anthracene	0.2	0.00014
Benzo(a)anthracene	0.2	0.00014
Benzo(b)fluoranthene	0.4	0.00028
Benzo(g,h,i)perylene	0.4	0.00028
Benzo(k)fluoranthene	0.4	0.00028
Bis(2-ethylhexyl)phthalate	1.4	0.0010
4-Bromophenyl phenyl ether	0.4	0.00028
Benzylbutylphthalate	0.6	0.00042
Camphene	1.0	0.00070
1-Chloronaphthalene	0.8	0.00056
2-Chloronaphthalene	0.9	0.00063
4-Chlorophenyl phenyl ether	0.9	0.00063
Bis(2-chloroisopropyl)ether	1.5	0.0011
Bis(2-chloroethyl)ether	1.8	0.0013
Bis(2-chloroethoxy)methane	1.3	0.00091
Chrysene	0.3	0.00021
Dibenz(a,h)anthracene	0.4	0.00028
1,2-Dichlorobenzene	0.02	0.00014
1,4-Dichlorobenzene	0.02	0.00014
Hexachlorobenzene	0.02	0.00014
Pentachlorobenzene	0.02	0.00014
Tetrochlorobenzenes	0.02	0.00014
Trichlorobenzenes	0.02	0.00014
Di-n-butylphthalate	1.1	0.00077
Di-n-octylphthalate	0.8	0.00056
2,4-Dinitrotoluene	0.5	0.00035
2,6-Dinitrotoluene	0.6	0.00042

TABLE 5.3.1.2 (cont.) **PROPOSED POLLUTION CONTROL CRITERIA FOR WASTEWATER DISCHARGE TO THE RECEIVING WATER BODY FOR GROUP 2A POLLUTANTS**

Contaminant	Concentration (ug/L) Maximum Daily	Process Weight (g/tonne crude steel) 30-day average
Dioxins (1)	0.000015	0.015×10^{-6}
Diphenylamine	1.9	0.0014
Ethylbenzene	0.4	0.00028
Fluoranthene	0.2	0.00014
Fluorene	0.4	0.00028
Furans (1)	0.000015	0.015×10^{-6}
Indeno(1,2,3-cd)pyrene	0.6	0.00042
Indole	1.2	0.00084
1-Methyl naphthalene	2.2	0.0016
2-Methyl naphthalene	1.5	0.0011
Methylene chloride	1.3	0.00091
5-Nitroacenaphthne	1.8	0.0013
N-Nitrosodiphenylamine	1.9	0.0014
N-Nitrosodi-n-propylamine	2.1	0.0015
Perylene	0.3	0.00021
Phenanthrene	0.3	0.00021
Pyrene	0.3	0.00021
Styrene	0.4	0.00028
Toluene	0.4	0.00028
Xylene-o	0.4	0.00028
Xylene-m and p	0.5	0.00035

Notes: (1) Toxic equivalent factor (TEF), NATO Protocol

TABLE 5.3.1.3 PROPOSED POLLUTION CONTROL CRITERIA FOR WASTEWATER DISCHARGE TO THE RECEIVING WATER BODY FOR GROUP 2B POLLUTANTS

Contaminant (1)	Concentration (mg/L) Maximum Daily	Process Weight (g/tonne crude steel) 30-day average
Aluminum	0.1	0.07
Antimony	0.05	0.035
Arsenic	0.04	0.028
Beryllium	0.02	0.014
Cadmium	0.001	0.0007
Cobalt	0.1	0.07
Copper	0.1	0.07
Mercury	0.001	0.0007
Molybdenum	0.1	0.07
Nickel	0.2	0.14
Phosphorus as P	0.5	0.35
Selenium	0.01	0.007
Tin	0.2	0.14
Vanadium	0.1	0.07

(1) Total unless otherwise specified

5.3.1.3 Precipitation Run-off Water

The model process also includes a lagoon for the precipitation run-off water with a retention time of five days. The proposed pollution control criteria, concentration only, contained in Table 5.3.1.1 would apply to all discharges from this lagoon. If the discharge value exceeds the proposed pollution control criteria, the source of the pollution would have to be located and either eliminated or diverted to one of the treatment plants.

5.3.2 Air Emissions

5.3.2.1 Introduction

The proposed pollution control criteria for air emissions are detailed in Section 5.2 and are summarized below. The estimated process weights are also normalized to the common denominator of production of crude steel (ie: molten steel leaving the melting furnace). The pollution control criteria for particulate are summarized in Table 5.3.2.1, for SO_x in Table 5.3.2.2, for NO_x in Table 5.3.2.3 and for miscellaneous pollutants in Table 5.3.2.4.

TABLE 5.3.2.1 SUMMARY OF POLLUTION CONTROL EMISSION CRITERIA FOR PLANT (PARTICULATE)

Process or operation	Concentration (mg/Nm^3)	Process Weight (unit)	Process Weight (kg/ tonne)	(1) (kg/tonne steel)
Raw materials handling & storage				
Rail car unloading	20			
Iron ore storage		(iron)	0.06	0.046
Iron pellet storage		(iron)	0.005	0.0038
Coal storage		(iron)	0.015	0.012
Sintering				
Wind-box	25	(sinter)	0.10	0.11
Discharge	20	"	0.05	0.061
Cooler	20	"	0.05	0.061
Building fugitive	20	"	0.003	0.0036
Crush & screen	20	"	0.003	0.0035

Note: (1) Process weight is estimated and is not a pollution control criterion.

TABLE 5.3.2.1 (continued) SUMMARY OF POLLUTION CONTROL EMISSION CRITERIA FOR PLANT (PARTICULATE)

Process or operation	Concentration (mg/Nm^3	Process Weight (1) (unit)	(kg/ tonne)	(kg/tonne steel)
Coke plant				
Crush & screen	20	(coke)	0.0016	0.0004
Preheating	30	"	0.12	0.029
Charging	...	"	0.008	0.0019
Door leaks	...	"	0.030	0.0072
Lid leaks	...	"	0.020	0.0048
Off-take leaks	...	"	0.020	0.0048
Pushing	20	"	0.020	0.0048
Wet quenching	40	"	0.20	0.048
Dry quenching *	40	"	0.10	0.024
Combustion stack	35	"	0.055	0.013
Coke crush & screen	20	"	0.002	0.0005
Iron making				
Raw materials	20	(Iron)	0.0016	0.0012
Cast house	20	"	0.012	0.009
Slag pouring	30	"	0.004	0.003
Slag crushing	20	"	0.010	0.008
Desulphurization	20	"	0.003	0.0023
Combustion stack	10	"	0.015	0.012
Ladle cleaning	20	"	0.003	0.0023
Steel making				
Raw materials	20	(Steel)	0.0005	0.0005
BOF	35	"	0.0070	0.0070
Charging	20	"	0.0003	0.0003
Tapping	20	"	0.0009	0.0009
Slagging	20	"	0.0007	0.0007
Hot metal transfer	20	"	0.0010	0.0010
Slag crushing	20	"	0.0010	0.0010

Notes: (1) Process weight is estimated and is not a pollution control criterion.

* LAER

TABLE 5.3.2.1 (continued) SUMMARY OF POLLUTION CONTROL EMISSION CRITERIA FOR PLANT (PARTICULATE)

Process or operation	Concentration (mg/Nm^3	Process Weight		(1)
		(unit)	(kg/ tonne)	(kg/tonne steel)
Electric arc furnace				
Melting, refining,	20	"	0.0090	0.0090
charging & tapping	(12) *	"	0.0050	0.0050
Slag crushing	20	"	0.0050	0.0050
Hot forming				
Reheating furnaces	10	(steel)	0.004	0.0044
Scarfer	25	"	0.012	0.013
Cold forming				
Acid pickle	20	"	0.002	0.0023
Hot coating	20	"	0.001	0.0012
Annealing	10	"	0.001	0.0012
Utilities				
Steam generation	40	"	0.013	0.013

Notes: (1) Process weight is estimated and is not a pollution control criterion.

* LAER

Estimated total particulate for integrated basic steel plant is 0.28 kg/tonne of crude steel (excludes sinter plant and electric arc furnace operations).

TABLE 5.3.2.2 **SUMMARY OF POLLUTION CONTROL EMISSION CRITERIA FOR PLANT (SO_x)**

Process or operation		Concentration (mg/Nm^3	Process Weight (unit)	(kg/ tonne)	(1) (kg/tonne steel)
Sinter plant					
Sinter wind-box		450	(sinter)	1.69	2.03
	*	(50)	"	(0.19)	(0.24)
Coke plant					
Combustion stack		20	(coke)	0.040	0.010
Blast furnace					
Combustion stack		...	(iron)	.....	.....
Hot forming					
Reheat furnaces		20	(steel)	0.008	0.010
Utilities					
Steam generation		10	(steel)	0.003	0.003

Notes: (1) Process weight is estimated and is not a pollution control criterion.

* LAER

TABLE 5.3.2.3 SUMMARY OF POLLUTION CONTROL EMISSION CRITERIA FOR PLANT (NO_x)

Process or operation	Concentration (mg/Nm^3	Process Weight (unit)	(kg/ tonne)	(1) (kg/tonne steel)
Sinter plant				
Sinter wind-box	350	(sinter)	1.31	1.59
	* (100)	"	(0.38)	(0.46)
Coke plant				
Combustion stack	300	(coke)	0.42	0.096
	* (90)	"	0.14	0.03
Blast furnace				
Combustion stack	80	(iron)	0.12	0.092
Hot forming				
Reheat furnaces	100	(steel)	0.040	0.043
	* (30)	"	(0.012)	(0.013)
Cold forming				
Anneal furnaces	100	(steel)	0.012	0.014
	* (40)	"	(0.005)	(0.006)
Utilities				
Steam generation	270	(steel)	0.08	0.08
	* (90)	"	(0.03)	(0.03)

Notes: (1) Process weight is estimated and is not a pollution control criterion.

* LAER

TABLE 5.3.2.4 SUMMARY OF POLLUTION CONTROL EMISSION CRITERIA FOR PLANT (MISCELLANEOUS)

Process or operation	Concentration (mg/Nm^3	Process Weight (1)		
		(unit)	(g/tonne tonne)	(g/tonne steel)
Sinter plant windbox				
Manganese	0.13	(sinter)	0.035	0.042
Fluoride as F	0.10	(sinter)	0.027	0.032
Blast furnace stove stack				
Dioxins (2)	0.5×10^{-6}	(iron)	0.1×10^{-6}	0.08×10^{-6}
Coke plant				
Benzene (LAER)	...	(coke)	7.0	1.8
Arsenic	...	(coke)	0.2	0.05
Mercury	...	(coke)	0.02	0.005
Steel making - BOF				
Copper	0.04	(steel)	0.005	0.005
Cadmium	0.0008	"	0.0001	0.0001
Manganese	0.8	"	0.10	0.10
Zinc	1.6	"	0.20	0.20
Dioxins (2)	0.5×10^{-6}	"	0.1×10^{-6}	0.1×10^{-6}
Steel making - Electric furnace				
Copper	0.01	(steel)	0.005	0.005
Cadmium	0.0004	"	0.00002	0.00002
Manganese	2.0	"	0.10	0.10
Zinc	2.6	"	0.13	0.13
Dioxins (2)	0.5×10^{-6}	(steel)	0.25×10^{-6}	0.25×10^{-6}
Acid pickling				
HCl fume	5	(steel)	0.8	0.9
Cold-rolling oil mist	15	(steel)	5.0	6.0

Notes: (1) Process weight is estimated and is not a pollution control criterion.

(2) Toxic equivalent factor (TEF) NATO Protocol

Process fugitive emissions:

Process fugitive emissions are defined as those emissions that are not collected and treated in a pollution control system. There are a multitude of process fugitive emission sources in a steel plant. The following examples illustrate the types of emission sources:

Fugitive emissions not captured by pollution control system

The collection and hooding systems for the capture of air pollutants may not capture all the emissions due to improper design, inadequate maintenance, process changes or other reasons. In some cases process variability may cause intermittent surges of emissions which exceed the capacity of the collection system. Examples include coke oven charging and pushing, blast furnace tapping, basic oxygen furnace charging, tapping and blowing and electric arc furnace operations.

These types of process fugitive emissions are minimized or eliminated through good collection and hooding system design, installation, operation and maintenance. They have been discussed in the relevant sections.

Tank vents and miscellaneous minor sources

Storage tanks containing volatile liquids such as gasoline will have minor fugitive emissions from vents and liquid transfer. Fugitive emissions containing benzene are discussed in Section 4.1.3. Other fugitive emissions from storage tanks are generally minor and can be minimized by good design, operation and maintenance and, in some cases, by the use of vent filters, vent vapour control systems or by the use of floating roof tanks.

Other miscellaneous sources include maintenance operations such as metal welding and cutting, refractory or building demolition and repair and similar operations. These are usually of an intermittent nature occurring in many plant locations. Good operating practice will minimize these emissions In those cases where the emission amounts are significant, hooding and collection may be necessary. Scrap-cutting in the scrap yard or melt shop or hand scarfing for steel conditioning can generate significant emissions and should be hooded and controlled where feasible or located in a building where the building exhaust air can be collected and controlled.

Other miscellaneous sources include the transportation of hot metal from the blast furnace to the steel melt shop (see Section 4.1.4 for discussion) or the transport of hot metal within the melt shop. In this latter case, most of the emissions may be collected by an auxiliary hood such as the canopy hood used in some electric furnace shops or by collection of the emissions at the roof monitor if the emissions create a significant problem.

Non-process fugitive emissions:

Non-process fugitive emissions and the proposed measures for fugitive emission control are as follows:

Plant roadways: Fugitive emissions are caused by vehicular traffic and wind action.

All heavily-travelled plant roadways should be paved and mechanically cleaned on a routine basis in dry weather to prevent dust build-ups that result in fugitive emissions.

Roadways that are not paved should be treated with a non-polluting dust suppressant during dry weather.

Parking lots: Same as plant roadways.

Material transport: Vehicles transporting materials, especially those that are prone to particulate emissions, should have the material being transported completely enclosed.

Trucks: Trucks and other heavy vehicles will pick up extraneous materials if they have been in areas where such materials are prevalent. A vehicle washing station should be installed at the exit of the plant so that such vehicles can be washed before leaving the plant to avoid the deposit of particulate material on roadways outside the plant.

5.3.3 Solid Waste

All wastes including solid wastes are subject to provisions of the Province of British Columbia's Waste Management Act (effective 1982) and Special Waste Regulation (effective April 1, 1988) under the act, B.C. Reg. 63/88 O.C. 268/88.

Materials which are special wastes according to the Special Waste Regulation are subject to special requirements for handling, transportation, storage, treatment and disposal. Recycling of special wastes is exempt from the requirements of certain sections of the Waste Management Act and the Special Waste Regulation provided the conditions specified in Section 2(8) of the Regulation are met. Before any waste is managed in British Columbia it is necessary to determine whether it is a special waste. Some wastes are special waste by definition but most require laboratory testing to determine whether they are special waste.

The significant solid wastes generated in the steel plant are listed below together with recommended management methods. Whichever method is selected for managing the waste, the onus is on the owner of the waste to determine the specific applicable regulatory requirements for that method at that time.

Methods of disposal of non-special waste are relatively simple and those for the special wastes are intentionally more involved. In either case the owner of the waste should contact the nearest office of the Waste Management Branch to discuss the possible management options.

The solid wastes generated by an integrated steel plant are listed below by plant process.

Sinter plant:

The solid wastes generated by the sinter plant will be recycled except for dust or sludge that has a high concentration of alkalis. This cannot be recycled and may be sold as a raw material for cement production. If it is not, it must be disposed of in a landfill site. The quantity of this solid waste is 3 kg per tonne of sinter (4 kg per tonne of crude steel) or less.

Coke ovens:

The majority of the solid wastes generated by the coke oven plant will be recycled or sold as by-products.

- Coke breeze - 50 to 100 kg/tonne of coal (22 to 45 kg/tonne of steel), recycled to coke ovens, used as reductant in sinter plant or electric arc furnaces or is sold to foundries as a reductant.
- Tar - 30 to 45 litres per tonne of coal (13 to 20 litres per tonne of steel), sold as a by-product to a chemical company, used as fuel in steel plant or for injection into the blast furnace.
- Ammonium sulphate, if produced as part of the coke oven gas cleaning process - 10 to 145 kg/tonne of coal (4.5 to 65 kg/tonne of steel), sold as a by-product.
- Light oil - 9.5 to 15 litres per tonne of coal (4 to 7 litres per tonne of steel); is sold as a by-product
- Elemental sulphur, if produced by the desulphurization of coke oven gas - approximately 5 kg/tonne of coal (2.2 kg/tonne of steel), sold as a by-product.

- Biological treatment plant sludge - approximately 9 kg/tonne of coke (2.8 kg/tonne of steel) containing trace quantities of PAHs, added to the coal being charged into the coke ovens and recycled (one Japanese steel company reported the incineration of the sludge).

Iron making:

The majority of the solid wastes generated by the iron making will be recycled or sold as by-products.

- Blast furnace slag - 170 to 340 kg/tonne of iron (130 to 260 kg/tonne of steel), usually processed by a third party off-site where it is crushed, iron values recovered and screened. Iron values are recycled to the blast furnace and the crushed slag is sold as construction aggregate. Depending on market conditions, some slag may have to be disposed of to landfill. The slag is relatively inert, will usually pass leachability tests and is suitable for landfill.

- Desulphurization slag - 2.25 to 15 kg/tonne of iron (2 to 12 kg/tonne of steel), processed for recovery of iron values, crushed and screened. Some of the slag, depending on the desulphurization process and resulting slag composition, is recycled to the blast furnace as flux and the balance is disposed of to landfill.

- Dust catcher material - the larger fraction of the dust leaving the blast furnace, processed in a pug mill with water addition for recycling to the blast furnace.

- Blast furnace sludge from pollution control - 40 to 45 kg/tonne of iron (30 to 35 kg/tonne of steel), recycled to the sinter plant if there is one or briquetted and recycled to the blast furnace if the zinc and lead concentrations are low.

If the lead and zinc concentrations are high or the sludge cannot be recycled for other reasons, the sludge is stockpiled in the steel plant for future recycling. The storage site must meet the requirements of the Special Waste Regulation.

Steel making:

- Dust from pollution control system for flux handling - 0.05 kg/tonne of steel, recycled to either blast furnace or steel-making furnace as flux.

- Sludge from vacuum degassing pollution control system - 0.3 kg/tonne of steel, usually included with steel-making solid waste.

- Sludge from continuous casting pollution control system - 0.35 kg/tonne of steel, usually included with steel-making solid waste.

Steel making - basic oxygen process:

- Slag - 140 kg/tonne of steel, usually processed by a third party off-site where it is crushed, iron values recovered and screened. Iron values are recycled to the steel-making furnace. Part of the crushed slag is recycled to the blast furnace as flux and the balance is usually sold as construction aggregate. The proportion used as flux varies according to the operating practice of the plant and the resulting composition of the slag. Depending on market conditions, some slag may have to be disposed of to landfill. The slag is relatively inert, will usually pass leachability tests and is suitable for landfill.

- Secondary steel-making slag - 5 to 15 kg/tonne of steel, processed for recovery of iron values and usually disposed of to landfill .

- Steel-making dust and sludge from pollution control - approximately 19 kg/tonne steel, recycled to the sinter plant if there is one unless the oil or zinc content is too high. Some, with low zinc content, may be briquetted and recycled to the blast furnace. The balance is usually stockpiled in the steel plant for future recycling. The storage site must meet the requirements of the Special Waste Regulation.

Steel making - electric furnace process:

- Slag - 150 kg/tonne of steel, usually processed by a third party off-site where it is crushed, iron values recovered and screened. Iron values are recycled to the steel-making furnace. Part of the crushed slag is usually sold as construction aggregate. Depending on market conditions and the zinc content, some slag may have to be disposed of to landfill.

  The slag is relatively inert but if it has a high zinc content, it may not be suitable for landfill and may have to be disposed to a special waste site.

- Secondary steel-making slag - 5 to 15 kg/tonne of steel, processed for recovery of iron values and usually disposed of to landfill.

- Steel-making dust and sludge from pollution control - 8 to 9 kg/tonne steel, usually high in zinc and must be disposed of to a special waste site. There are high temperature processes available that recover the zinc and produce a pellet that is recyclable, but these processes are not economic for low volumes of dust.

Hot forming:

- Steel scrap - recycled to steel making.
- Mill scale and pollution control system sludge - approximately 60 kg/tonne of steel, the coarse fraction, approximately 90 percent, of the sludge is recycled within the steel plant to the sinter plant, blast furnace and steel-making furnaces while the fine fraction which contains some oil is usually disposed of to landfill.

Cold forming:

- Steel scrap - recycled to steel making.
- Iron oxide from acid regeneration - 1.5 to 3 kg/tonne of steel pickled, recycled to the sinter plant or the blast furnace or sold as a by-product.
- Sludge from pollution control systems - approximately 0.3 kg/tonne of steel, usually disposed of to landfill or special waste site due to concentrations of oil and trace metals contained in sludge.
- Blowdown treatment plant sludge - approximately 0.06 kg/tonne of steel, disposed of to special waste site due to concentrations of trace metals and criteria pollutants.

Miscellaneous:

- Waste oil - recovered from hot-forming, cold-forming and miscellaneous minor sources - 1.5 to 3 kg/tonne of steel, recovered and processed for recycling to cold rolling and for use as in-plant fuel. In some cases processing is done by a third party off-site. Usually no waste oil requires disposal.

- Refractory materials from furnace repairs, etc. - 6.5 to 13 kg/tonne of steel, about one-third recycled within the plant and the balance disposed of to landfill.

- Paper products - unknown quantity, some collected and sold for recycling and the balance incinerated or disposed of to landfill.

- Wood from packaging, materials handling - unknown quantity, incinerated or disposed of to landfill.

- Solvents - unknown quantity, some recycled and balance disposed of to special waste site or incinerated.

- Miscellaneous - laboratory chemicals, empty paint, solvent and chemical containers, batteries, tires, etc. - unknown quantity, disposed of to recycling firms, landfill or special waste sites. Some metal containers may be recycled to steel making.

5.4 Proposed Compliance Monitoring Regime

5.4.0 Introduction

The proposed compliance monitoring regime is composed of three components:

1. Routine compliance monitoring of operations.

   - Monitoring that is carried out on a prescribed routine basis to determine compliance with the prescribed pollution control criteria.

2. Spill or upset monitoring of operations.

   - Monitoring required after a spill or operational upset that leads or may lead to the operation exceeding the prescribed pollution control criteria.

   - Monitoring required for the start of operations of any new production or pollution control facility.

3. Compliance monitoring in the receiving environment.

   - Monitoring required off-site to determine compliance with prescribed pollution control criteria, including:

     - water quality, biota and sediment monitoring in the effluent discharge mixing zone and in the water surrounding the discharge mixing zone.

     - ambient air quality in the territory surrounding the plant site.

     - waste disposal off-site including leachability and leachate monitoring.

Components (1) and (2) are outlined in the following sections. Component (3) will be prescribed by the Ministry of Environment for the specific site.

The compliance monitoring methods will be prescribed by the Ministry of Environment. Typical sampling and analytical methods are outlined in British Columbia's Ministry of Environment documents.

5.4.1 Wastewater Discharge

The proposed compliance monitoring regime for wastewater operates on two levels. The first level is the discharge to the receiving water body. The results from this monitoring level determine the regulatory compliance to the pollution control criteria.

The second level is the operational level (discharge from process wastewater treatment plants). The results from this monitoring level identify operational problems, upsets or spills that may cause the wastewater to the receiving water body to exceed the pollution control criteria.

The proposed compliance monitoring regime for the wastewater discharge to the receiving water body is shown in Table 5.4.1 for the pollution control parameters shown in Table 5.3.1.1, in Table 5.4.2 for the parameters shown in Table 5.3.1.2 and in Table 5.4.3 for the pollution control parameters shown in Table 5.3.1.3.

TABLE 5.4.1 PROPOSED COMPLIANCE MONITORING FOR WASTEWATER DISCHARGE TO THE RECEIVING WATER BODY FOR GROUP 1 POLLUTANTS (1)

Pollutant or parameter	Concentration	Process Weight (2)
Effluent flow	C	D
pH	C	....
Total suspended solids	D	D
Oil and grease	D	D
Ammonia - N	D	D
Cyanides (total)	D	D
Phenols	D	D
Benzene	D	D
Naphthalene	D	D
Benzo(a)pyrene	D	D
Total residual chlorine	C	D
Chromium (total)	D	D
Lead (total)	D	D
Zinc (total)	D	D
LC_{50} Fish Toxicity Test	C	....
Daphnia Magna Acute Lethality Toxicity Test	D	....

C	Continuous monitoring
D	Daily composite (0.00 hrs to 24.00 hrs)

(1) Proposed pollution control criteria in Table 5.3.1.1

(2) Process weight calculated on daily basis from results of daily composite and daily production of crude steel

TABLE 5.4.2 PROPOSED COMPLIANCE MONITORING FOR WASTEWATER DISCHARGE TO THE RECEIVING WATER BODY FOR GROUP 2A POLLUTANTS (1)

Pollutant	Concentration	Process Weight
Acenaphthene	Q	Q
Acenaphthylene	Q	Q
Anthracene	Q	Q
Benzo(a)anthracene	Q	Q
Benzo(b)fluoranthene	Q	Q
Benzo(g,h,i)perylene	Q	Q
Benzo(k)fluoranthene	Q	Q
Bis(2-ethylhexyl)phthalate	Q	Q
4-Bromophenyl phenyl ether	Q	Q
Benzylbutylphthalate	Q	Q
Camphene	Q	Q
1-Chloronaphthalene	Q	Q
2-Chloronaphthalene	Q	Q
4-Chlorophenyl phenyl ether	Q	Q
Bis(2-chloroisopropyl)ether	Q	Q
Bis(2-chloroethyl)ether	Q	Q
Bis(2-chloroethoxy)methane	Q	Q
Chrysene	Q	Q
Dibenz(a,h)anthracene	Q	Q
1,2-Dichlorobenzene	Q	Q
1,4-Dichlorobenzene	Q	Q
Hexachlorobenzene	Q	Q
Pentachlorobenzene	Q	Q
Tetrochlorobenzene	Q	Q
Trichlorobenzene	Q	Q
Di-n-butylphthalate	Q	Q
Di-n-octylphthalate	Q	Q
2,4-Dinitrotoluene	Q	Q
2,6-Dinitrotoluene	Q	Q

TABLE 5.4.2 (continued) PROPOSED COMPLIANCE MONITORING FOR WASTEWATER DISCHARGE TO THE RECEIVING WATER BODY FOR GROUP 2A POLLUTANTS (1)

Pollutant	Concentration	Process Weight
Dioxins (2)	Q	Q
Diphenylamine	Q	Q
Ethylbenzene	Q	Q
Fluoranthene	Q	Q
Fluorene	Q	Q
Furans (2)	Q	Q
Indeno(1,2,3-cd)pyrene	Q	Q
Indole	Q	Q
1-Methyl naphthalene	Q	Q
2-Methyl naphthalene	Q	Q
Methylene chloride	Q	Q
5-Nitroacenaphthne	Q	Q
N-Nitrosodiphenylamine	Q	Q
N-Nitrosodi-n-propylamine	Q	Q
Perylene	Q	Q
Phenanthrene	Q	Q
Pyrene	Q	Q
Styrene	Q	Q
Toluene	Q	Q
Xylene-o	Q	Q
Xylene-m and p	Q	Q

Q Average of daily composites for seven consecutive days once each quarter

Process weight calculated on basis of average of daily composites and quarter's crude steel production

See next page for notes.

TABLE 5.4.2 (continued) PROPOSED COMPLIANCE MONITORING FOR WASTEWATER DISCHARGE TO THE RECEIVING WATER BODY FOR GROUP 2A POLLUTANTS (1)

NOTES:

(1) Proposed pollution control criteria in Table 5.3.1.2

(2) Toxic equivalent factor (TEF), NATO Protocol

(3) If the pollution control criterion for a pollutant is exceeded for any monitoring period, the monitoring for that pollutant will continue on a daily basis until the pollution control criterion has been met for a 30-day consecutive period (average).

(4) If the monitoring results for any pollutant(s) are shown to have a positive correlation with the monitoring results of one or more pollutants in Table 5.4.1, the monitoring frequency for that pollutant(s) can be relaxed to one monitoring period a year.

TABLE 5.4.3 PROPOSED COMPLIANCE MONITORING FOR WASTEWATER DISCHARGE TO THE RECEIVING WATER BODY FOR GROUP 2B POLLUTANTS (1)

Pollutant (2)	Concentration	Process Weight
Aluminum	Q	Q
Antimony	Q	Q
Arsenic	Q	Q
Beryllium	Q	Q
Cadmium	Q	Q
Cobalt	Q	Q
Copper	Q	Q
Mercury	Q	Q
Molybdenum	Q	Q
Nickel	Q	Q
Phosphorus as P	Q	Q
Selenium	Q	Q
Tin	Q	Q
Vanadium	Q	Q

NOTES:

(1) Proposed pollution control criteria in Table 5.3.1.3

(2) Total unless otherwise specified

(3) If the pollution control criterion for a pollutant is exceeded for any monitoring period, the monitoring for that pollutant will continue on a daily basis until the pollution control criterion has been met for a 30-day consecutive period (average).

(4) If the monitoring results for any pollutant(s) are shown to have a positive correlation with the monitoring results of one or more pollutants in Table 5.4.1, the monitoring frequency for that pollutant(s) can be relaxed to one monitoring period a year.

Precipitation Run-off

The proposed compliance monitoring regime for the precipitation run-off water for the pollution control parameters shown in Table 5.4.1 is shown in Table 3.2.4.

TABLE 5.4.4 **PROPOSED COMPLIANCE MONITORING FOR PRECIPITATION RUN-OFF DISCHARGE TO THE RECEIVING WATER BODY FOR GROUP 1 POLLUTANTS (1)**

Pollutant or parameter	Concentration
Effluent flow	D (2)
pH	D (2)
Total suspended solids	D (2)
Oil and grease	D (2)
Ammonia - N	D (2)
Cyanides (total)	(3)
Phenols	(3)
Benzene	(3)
Naphthalene	(3)
Benzo(a)pyrene	(3)
Chromium (total)	(3)
Lead (total)	(3)
Zinc (total)	(3)
LC_{50} Fish Toxicity Test	(4)
Daphnia Magna Acute Lethality Toxicity Test	(4)

D Daily composite (0.00 hrs to 24.00 hrs)

(1) Proposed pollution control criteria in Table 5.3.1.1

(continued)

TABLE 5.4.4 **PROPOSED COMPLIANCE MONITORING FOR PRECIPITATION RUN-OFF DISCHARGE TO THE RECEIVING WATER BODY FOR GROUP 1 POLLUTANTS**

Initial monitoring:

Before any water is released from the precipitation run-off lagoon after any precipitation event, a sample must be taken and analyzed for all pollution control criteria in this Table. If any pollution control criterion is exceeded, no water is to be released without the approval of the appropriate Ministry of Environment official.

Monitoring after precipitation events:

(2) Daily composite until discharge from lagoon ceases.

(3) Daily composite for three consecutive days after each major precipitation event (more than 5.0 mm equivalent precipitation) or until lagoon discharge ceases, whichever occurs first. Minimum of one daily composite for three consecutive days per calendar quarter. If the concentration exceeds the pollution control criteria, daily composite sampling to continue until the pollution control criteria have been met for seven consecutive days or until lagoon discharge ceases, whichever occurs first.

(4) Once each six-month period, at least three months apart. If the discharge fails a toxicity test, it should be repeated for each succeeding precipitation event until criteria are met. Daily monitoring for all other pollutants until the discharge meets the toxicity test criterion.

5.4.2 Air Emissions

The compliance monitoring methods for air emissions are prescribed by the Ministry of Environment.

The emissions from all controlled sources are subject to an emission stack test within 180 days of start-up or major modification unless exempted by the Ministry of Environment and are to be repeated within 60 days if the pollution control criteria for that source are not met. Major modification is defined as a process modification, equipment modification or air pollution control modification that individually or collectively has the potential to increase the air emissions from the individual production unit by more than 20 percent or the total plant by more than five percent.

The emissions from all controlled sources are subject to an emission stack test once each year unless otherwise specified. Emissions from uncontrolled sources such as storage tank vents are to be estimated and emission stack testing will be waived unless requested by the Ministry of Environment.

If for any reason the pollutant control criteria are not met for any emission stack test, the emission stack test will be repeated within 60 days.

The proposed compliance monitoring regimes for the individual process units are outlined in the following sections.

TABLE 5.4.2.1 PROPOSED COMPLIANCE MONITORING REGIME FOR SINTER PLANT EMISSIONS (1)

Process or operation	Pollutant	Frequency
Sinter wind-box	Particulate	A
	Manganese	A (2)
	SO_x	C
	NO_x	Q
	Fluoride as F	A (2)
Sinter discharge	Particulate	A (2)
Sinter building fugitives	Particulate	A (2)
Sinter crushing and screening	Particulate	A (2)

C	Continuous emission monitoring
Q	Stack test once each calendar quarter
A	Stack test once each year, at least six months apart

(1) Proposed pollution control criteria in Table 5.2.1.2

(2) May be less frequent at the discretion of the Ministry

TABLE 5.4.2.2 PROPOSED COMPLIANCE MONITORING REGIME FOR BY-PRODUCT COKE PLANT EMISSIONS (1)

Process or operation	Pollutant	Frequency
Coal crushing and handling	Particulate	A (2)
Coal preheating	Particulate	A
Charging (Wet coal)	Particulate	(3)
Door leaks	Particulate	(3)
Lid leaks	Particulate	(3)
Off-takes	Particulate	(3)
Pushing	Particulate	A (3)
Wet quenching	Particulate	A (4)
Combustion stack	Particulate	A (4)
	SO_x	A (5)
	NO_x	A (2)
Coke crushing and screening	Particulate	A (2)
Fugitive emissions	Benzene	(3)

M	Stack test once each calendar month
A	Stack test once each year, at least six months apart

(1) Proposed pollution control criteria and control measures in Tables 5.2.1.5, 5.2.1.6 and 5.2.1.7

(2) May be less frequent at the discretion of the Ministry

(3) Visual inspection daily

(4) Visual inspection daily, emission stack test annually

(5) Sulphur content of coke oven gas tested monthly

TABLE 5.4.2.3 **PROPOSED COMPLIANCE MONITORING REGIME FOR BLAST FURNACE EMISSIONS (1)**

Process or operation	Pollutant	Frequency
Raw materials handling	Particulate	A (2)
Cast house tapping	Particulate	A (2)
Slag pouring	Particulate	A (2)
Slag granulation	Particulate	A (2)
Slag crushing and screening	Particulate	A (2)
Hot metal desulphurization	Particulate	A (2)
Combustion stack	Particulate	A (3)
	NO_x	A (5)
	Dioxins	A (2)
Ladle cleaning	Particulate	A (2)

A Stack test once each year, at least six months apart

(1) Proposed pollution control criteria in Table 5.2.1.10 and control measures in Table 5.2.1.11

(2) May be less frequent at the discretion of the Ministry

(3) Visual inspection daily, annual stack test may be waived

(5) Annual stack test may be waived

Blast furnace slips to be reported daily

TABLE 5.4.2.4 PROPOSED COMPLIANCE MONITORING REGIME FOR STEEL-MAKING EMISSIONS (1)

Process or operation	Pollutant	Frequency
Raw materials handling	Particulate	A (2)
Melting & refining	Particulate	A (3)
	Copper	A (2)
	Cadmium	A (2)
	Manganese	A (2)
	Zinc	A (2)
	Dioxins	A (2)
Charging	Particulate	A (2)
Tapping	Particulate	A (2)
Slagging	Particulate	A (2)
Hot metal transfer	Particulate	A (2)
Slag crushing	Particulate	A (2)
Continuous casting	Particulate	A (2)

A Stack test once each year, at least six months apart

(1) Proposed pollution control criteria in Table 5.2.2.2 and control measures in Table 5.2.2.3

(2) Stack testing may be less frequent at the discretion of the Ministry

(3) Visual inspection daily, stack testing may be less frequent at the discretion of the Ministry

TABLE 5.4.2.5 **PROPOSED COMPLIANCE MONITORING REGIME FOR HOT-FORMING EMISSIONS (1)**

Process or operation	Pollutant	Frequency
Reheating furnace	Particulate	A (2)
	SO_x	A (3)
	NO_x	A (4)
Scarfer	Particulate	A (4)

A Stack test once each year, at least six months apart

(1) Proposed pollution control criteria in Table 5.2.3.2

(2) Annual stack test may be waived for gaseous fuels

(3) Annual stack test may be waived for fuels with very low or no sulphur content

(4) Annual stack test may be waived

TABLE 5.4.2.6 PROPOSED COMPLIANCE MONITORING REGIME FOR COLD-FORMING EMISSIONS (1)

Process or operation	Pollutant	Frequency
Cold rolling	Oil mist	A (2)
Acid pickling	Particulate	A (2)
	Acid fume	C
Acid regeneration	Particulate	A (2)
	Acid fume	C
Annealing furnaces	Particulate	A (3)
	SO_x	A (4)
	NO_x	A (2)
Hot coating	Particulate	A (2)

C	Continuous monitoring
A	Stack test once each year, at least six months apart

(1) Proposed pollution control criteria in Table 5.2.4.3

(2) Annual stack test may be waived

(3) Annual stack test may be waived for gaseous fuels

(4) Annual stack test may be waived for fuels with very low or no sulphur content

TABLE 5.4.2.7 PROPOSED COMPLIANCE MONITORING REGIME FOR CENTRAL BOILER HOUSE EMISSIONS (BACT) (1)

Process or operation	Pollutant	Frequency
Combustion	Particulate	A (2)
	SO_x	A (3)
	NO_x	A (2)

A	Stack test once each year, at least six months apart
(1)	Proposed pollution control criteria in Table 5.2.5.1
(2)	Annual stack test may be waived
(3)	Continuous monitoring may be required depending on sulphur content of fuel

5.4.3 Solid Waste

All wastes including solid wastes are subject to provisions of the Province of British Columbia's Waste Management Act (effective 1982) and Special Waste Regulation (effective April 1, 1988) under the act, B.C. Reg. 63/88 O.C. 268/88.

Materials which are special wastes according to the Special Waste Regulation are subject to special requirements for handling, transportation, storage, treatment and disposal. Recycling of special wastes is exempt from the requirements of certain sections of the Waste Management Act and the Special Waste Regulation provided the conditions specified in Section 2(8) of the Regulation are met. Before any waste is managed in British Columbia, it is necessary to determine whether it is a special waste. Some wastes are special waste by definition but most require laboratory testing to determine whether they are special waste.

The significant solid wastes generated in the steel plant are listed below together with recommended management methods. Whichever method is selected for managing the waste, the onus is on the owner of the waste to determine the specific regulatory requirements applicable for that method at that time.

Methods of disposal of non-special waste are relatively simple but those for the Special Wastes are intentionally more involved. In either case the owner of the waste should contact the nearest office of the Waste Management Branch to discuss the possible management options.

5.4.4 Unit Process Wastewater Discharge

The proposed voluntary monitoring regimes for the wastewater from the process treatment plants are shown in the following tables.

Sinter Plant

The proposed voluntary monitoring regime for sinter plants is shown in Table 5.4.4.1 for the pollution control parameters shown in Table 5.2.1.1.

TABLE 5.4.4.1 PROPOSED VOLUNTARY MONITORING FOR SINTER PLANT PROCESS TREATMENT PLANT WASTEWATER DISCHARGE

Pollutant or parameter	Concentration	Process Weight
Effluent flow	C	D
pH	C	....
Total suspended solids	D	D
Oil and grease	W	W

C Continuous monitoring

D Daily composite (0.00 hrs to 24.00 hrs)

W Daily composite (0.00 hrs to 24.00 hrs) once each calendar week

Coke Plant

The proposed voluntary monitoring regime for coke plants is shown in Table 5.4.4.2 for the pollution control parameters shown in Table 5.2.1.4.

TABLE 5.4.4.2 PROPOSED VOLUNTARY MONITORING FOR COKE PLANT PROCESS TREATMENT PLANT WASTEWATER DISCHARGE

Pollutant or parameter	Concentration	Process Weight
Effluent flow	C	D
pH	C	....
Total suspended solids	D	D
Oil and grease	W	W
Ammonia - N	D	D
Cyanides (total)	D	D
Phenols	D	D
Benzene	D	D
Naphthalene	W	W
Benzo(a)pyrene	W	W

C	Continuous monitoring
D	Daily composite (0.00 hrs to 24.00 hrs)
W	Daily composite (0.00 hrs to 24.00 hrs) once each calendar week

Blast Furnace

The proposed voluntary monitoring regime for blast furnaces is shown in Table 5.4.4.3 for the pollution control parameters shown in Table 5.2.1.9.

TABLE 5.4.4.3 **PROPOSED VOLUNTARY MONITORING FOR BLAST FURNACE PROCESS TREATMENT PLANT WASTEWATER DISCHARGE**

Pollutant or parameter	Concentration	Process Weight
Effluent flow	C	D
pH	C	....
Total suspended solids	D	D
Oil and grease	W	W
Ammonia - N	W	W
Cyanides (total)	W	W
Phenols	W	W
Lead (total)	W	W
Zinc (total)	W	W

C	Continuous monitoring
D	Daily composite (0.00 hrs to 24.00 hrs)
W	Daily composite (0.00 hrs to 24.00 hrs) once each calendar week

Steel Making

The proposed voluntary monitoring regime for steel making is shown in Table 5.4.4.4 for the pollution control parameters shown in Table 5.2.2.1.

TABLE 5.4.4.4 PROPOSED VOLUNTARY MONITORING FOR STEEL-MAKING PROCESS TREATMENT PLANT WASTEWATER DISCHARGE

Pollutant or parameter	Concentration	Process Weight
Effluent flow	C	D
pH	C	....
Total suspended solids	D	D
Lead (total)	W	W
Zinc (total)	W	W

C	Continuous monitoring
D	Daily composite (0.00 hrs to 24.00 hrs)
W	Daily composite (0.00 hrs to 24.00 hrs) once each calendar week

Hot Forming

The proposed voluntary monitoring regime for hot forming is shown in Table 5.4.4.5 for the pollution control parameters shown in Table 5.2.3.1.

TABLE 5.4.4.5 PROPOSED VOLUNTARY MONITORING FOR HOT-FORMING PROCESS TREATMENT PLANT WASTEWATER DISCHARGE

Pollutant or parameter	Concentration	Process Weight
Effluent flow	C	D
pH	C	....
Total suspended solids	D	D
Oil and Grease	D	D
Lead (total)	W	W
Zinc (total)	W	W

C	Continuous monitoring
D	Daily composite (0.00 hrs to 24.00 hrs)
W	Daily composite (0.00 hrs to 24.00 hrs) once each calendar week

Cold Forming

The proposed voluntary monitoring regime for cold forming is shown in Table 5.4.4.6 for the pollution control parameters shown in Table 5.2.4.2.

TABLE 5.4.4.6 PROPOSED VOLUNTARY MONITORING FOR COLD-FORMING PROCESS TREATMENT PLANT WASTEWATER DISCHARGE

Pollutant or parameter	Concentration	Process Weight
Effluent flow	C	D
pH	C	....
Total suspended solids	D	D
Oil and Grease	D	D
Chromium (total)	W	W
Lead (total)	W	W
Zinc (total)	W	W

C	Continuous monitoring
D	Daily composite (0.00 hrs to 24.00 hrs)
W	Daily composite (0.00 hrs to 24.00 hrs) once each calendar week

Blowdown Treatment Plant

The proposed voluntary monitoring regime for the blowdown treatment plant is shown in Table 5.4.4.7 for the pollution control parameters shown in Table 5.2.6.2.

TABLE 5.4.4.7 PROPOSED VOLUNTARY MONITORING FOR BLOWDOWN TREATMENT PLANT WASTEWATER DISCHARGE

Pollutant or parameter	Concentration	Process Weight
Effluent flow	C	D
pH	C	....
Total suspended solids	D	D
Oil and Grease	D	D
Ammonia - N	D	D
Cyanides (total)	D	D
Phenols	W	W
Benzene	W	W
Naphthalene	W	W
Benzo(a)pyrene	D	D
Total residual chlorine	C	D
Chromium (total)	W	W
Lead (total)	W	W
Zinc (total)	W	W

C	Continuous monitoring
D	Daily composite (0.00 hrs to 24.00 hrs)
W	Daily composite (0.00 hrs to 24.00 hrs) once each calendar week

6.0 REFERENCE MATERIAL

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APPENDIX A

SUMMARY OF POLLUTION CONTROL REGULATIONS AFFECTING IRON AND STEEL PLANTS FROM SELECTED JURISDICTIONS

A 1.0 International Pollution Standards and Criteria for Steel Production

A 1.1 Introduction:

A preliminary review of environmental legislation related to the integrated iron and steel industry was conducted for a number of countries including the United States, Japan, the United Kingdom, France, West Germany, Sweden and the Republic of China (Taiwan).

The review involved a search of environmental literature including CanOle, Dobis, Elias and Enviroline bibliographic databases, other material at CISTI and Environment Canada, material collected by the Ministry of Environment of British Columbia and material supplied by steel companies and environmental protection agencies.

Regulations, standards and other environmental control requirements of the US EPA and State agencies are included in the appropriate chapters of Volume 2 and are not repeated in this Appendix.

Any comparative analysis of international emission and effluent standards and criteria must take into account all factors that determine the actual or operational levels of effluent or emissions for the specific jurisdiction. These factors include:

- Enforcement of local standards vis à vis national standards. Examples are State requirements versus EPA standards in the USA or regional requirements for sulphur oxides in Japan.

- Enforcement of ambient pollution criteria versus emission or effluent discharge criteria such as in Ontario.

- Enforcement of different standards for new versus existing operations such as the NSPS (New Source Performance Standards) in the USA.

- Enforcement of negotiated or other standards on a site specific basis through the use of permitting systems. Examples are Ontario's enforcement of their point of impingement criteria or in non-attainment areas in the USA.

- Development of standards that are not promulgated or enforced due to political or economic reasons as in the USSR.

- Standards that have differing time frames for implementation such as Sweden where some requirements have to be met now,others in 1991 and still others as late as 1995.

- Standards that vary according to the size of the polluting operation such as some in the Federal Republic of Germany.

- Standards that use a different base such as concentration (mg/Nm^3 or mg/l), mass per unit of production (kg/tonne product), mass discharge (kg/hour, kg/day or kg/year) or some combination of these. The N - "Normal" refers to one standard atmosphere and 20°C (293°K) for the gas.

- Effluent standards use different protocols for monitoring (e.g. 1 day, 20 day average) and are often difficult to determine on a national basis, often reflecting local permitting and informal arrangements.

In addition, some jurisdictions use different standards depending on the toxicity or health hazard of specific pollutants and local effects or impacts. This may vary from jurisdiction to jurisdiction.

Thus, the comparison of international pollution standards and criteria in this report is based on the compromise of comparing what is available and accepting that the comparison may not be precise due to the use of varying conditions or factors.

In the following tables two approaches are used. For both water effluent and air emission standards, tables have been provided with the general standards of the various countries. In the second set of tables, water effluent and air emission standards for specific production processes have been provided. The listing of standards is by no means complete.

Tables A 1.1.1, A 1.1.2, A1.1.3 and A 1.1.4 summarize the British Columbia Objectives and compare them to standards from other selected countries.

TABLE A 1.1.1 **Air Emission Discharge Limits - Summary of International Standards**
(mg/Nm^3 unless otherwise noted)

Parameter	British Columbia (range) (i)	Korea (ii)	ROC (Taiwan) (iii)	Japan (iv)	Ontario ($\mu g/Nm^3$) (v)	OECD Proposed 1986 (kg/tonne)				
						SINTER	COKE	BF METAL	STEEL PROD	ROLL. MILLS
Total particulate	23 - 184	150-300	700	100-150 (coke) 30-50 (B.F.)	100					
Antimony as Sb	7.4 - 12.4									
Arsenic as As	7.4 - 12.4									
Asbestos (vi) (fibres/cm^3)	less than 2									
Cadmium as Cd	2.4 - 12.4									
Copper as Cu	7.4 - 12.4									
Fluoride as HF	0.9 - 8.8				4.3					
Lead as Pb	7.4 - 12.4		10 (after 1990)							
Mercury as Hg	0.023									
Nitrogen Oxides as NO_2	581 - 1912	581	290-478	325 (coke) 191 (B.F.)	500	0.3	0.65	0.5	0.3	1.1
Opacity (percent)	10 - 40									
Sulphur Dioxide	665 - 2660	2128	1730-1995	Note vii	830	2.0	0.5	0.2	-	-
Zinc as Zn	7.4 - 12.4									
Carbon Monoxide			400 ppm		6000	30	1	10	15	-
HCl			80 ppm		100					
Cl_2			30 ppm		300					
NH_3			100 ppm		3600					
H_2SO_4 droplet			400 $\mu g/Nm^3$		100					

TABLE A 1.1.1 (continued) AIR EMISSION DISCHARGE LIMITS - SUMMARY OF INTERNATIONAL STANDARDS

NOTES:

(i) British Columbia (1979) Objectives for Gaseous and Particulate Emissions.

(ii) Korean Regulations, amended August 1987 (translation of).

(iii) The Emission Standards of Air Pollutants for stationary sources in Taiwan Province promulgated August 18, 1986.

(iv) Legal systems for environmental control in Japan, Japan Iron and Steel Foundation, May 29, 1986.

(v) Ontario Environmental Protection Act Regulation 308, 30 min. average at point of impingement.

(vi) An asbestos fibre greater than 6 μm in length with a length to breadth ratio of 3:1 or greater:

(vii) $q = K \bullet 10^3 \bullet He2 \bullet Nm^3/h$; $K = 1.17$ (new).

TABLE A 1.1.2 AIR EMISSION DISCHARGE LIMITS - COKE OVENS (BRITISH COLUMBIA AND CANADA)

Parameter	Units	British Columbia (1) (range)	Canada (2)
Total Particulate			
(a) Charging	kg/ tonne coke	0.1 - 0.2 (3)	0.1
(b) Pushing	mg/Nm^3	46 - 230 (3)	46
(c) Battery Stacks	mg/Nm^3	69 - 230	69
(d) Quenching	kg/ tonne coke	0.01 - 0.015	0.05
Opacity	percent	10 - 40 (4)	
Trace Elements		(5)	

NOTES: (1) British Columbia (1979) Objectives for Gaseous and Particulate Emissions.

(2) Environment Canada, National Emission Guidelines for Coke Ovens, 1975.

(3) To be measured in the discharge stream on the dust collecting equipment. Where meaningful sampling cannot be carried out, the opacity objectives will apply.

(4) Maximum allowable opacity for 90% of the time.

TABLE A 1.1.2 (continued)   AIR EMISSION DISCHARGE LIMITS - COKE OVENS (BRITISH COLUMBIA AND CANADA)

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(5) No ranges have been specified for polycyclic hydrocarbons or certain other reactive substances. Appropriate specification will be established by the Director should such a need develop. The degree of control required may require a reduction of total particulate emissions.

REFERENCES:
(i) British Columbia (1979) Objectives for the Discharge of Final Effluents to Marine and Fresh Water.
(ii) Personal communication Environment Canada 1989.
(iii) Korean Regulations, amended August 1987 (translation of).
(iv) Legal systems for environmental control in Japan, Japan Iron and Steel Foundation, May 29, 1986.
(v) Kanagawa Prefectural Regulations, December 1970.
(vi) Taiwan Water Pollution Control Act referenced in "Environmental control status in China Steel Corporation" 1989.

TABLE A 1.1.3 **FINAL EFFLUENT DISCHARGE LIMITS - SUMMARY OF INTERNATIONAL STANDARDS**

(mg/L)

Parameter	British Columbia (range) (1)	Canada (1977)	Korea	Japan (2)	Japan Kanayawa Prefecture (3)	Taiwan (4)
Total suspended solids (5)	25 - 75	25	100	70	70	
Total dissolved solids	2500 - 5000					
Toxicity (96 hour LC 50 static bioassay) (6)	100% - 80%					
pH (pH units)	6.5 - 8.5 6.5 - 10	6.0 mean	7.8 - 8.3	5.0-9.0 Coastal 5.8-8.6 Fresh		5 - 9
Radioactivity:						
Gross Alpha (pCi/L)	10 - 100					
Radium^{236} (pCi/L) (7)	<10					
Aluminum (Al)	0.5 - 1.0					
Ammonia (as N)	1.0 - 10.0					
Arsenic (as trivalent As)	0.05 - 0.25		0.05			0.5
Arsenic (total dissolved)	0.10 - 1.0	0.5		0.5	0.5	
Cadmium (Cd)	0.01 - 0.1		0.01	0.1	0.1	0.1
Chromium (Cr)	0.05 - 0.3		0.05	2 (Cr^{+6})	2(0.5 as Cr^{+6})	2
Cobalt (Co)	0.5 - 1.0					
Copper (Cu)	0.05 - 0.3	0.3	0.02	1	1	3
Cyanide (as CN)	0.1 - 0.5			1	1	1.0
Fluoride (F)	2.5 - 10.0		15	15	15	15
Iron (Fe)	0.3 - 1.0			3	3	
Lead (PB)	0.05 - 0.2	0.2	0.1		1	1.0
Manganese (Mn)	0.1 - 1.0			10	1	10
Mercury (Total Hg) (8)	nil - 0.005		N.D.	0.005	0.005	N.D. - org.
Molybdenum (Mo)	0.5 - 5.0					
Nickel (Ni)	0.2 - 1.0	0.5			1	1.0
Nitrate/nitrite (as N)	10.0 - 25.0		100			100
Phosphate (Total biological available in effluent)	2.0 - 10.0		N.D.	1	0.2	0.5
Selenium (Se)	0.05 - 0.5					0.5
Silver (Ag)	0.05 - 0.5					
Uranyl (UO_2)	2.0 - 5.0					
Zinc (Zn)	0.2 - 1.0	0.5		1	1	5
Oil and grease (Total)	10.0 - 15.0		5	5 - 30	5	10 - 30
Coliform				3000/cc	3000/cc	
BOD, COD			100	160	25	
PCB			N.D.	0.003	0.003	N.D.
Phenol				5.0	0.5	5.0
Anionic surfactant						10.0
Radium (pCi/L)		10				

TABLE A 1.1.3 (continued) FINAL EFFLUENT DISCHARGE LIMITS - SUMMARY OF INTERNATIONAL STANDARDS

NOTES:

(1) British Columbia (1979) - Objectives for the Discharge of Final Effluents to Marine and Fresh Water (mg/L dissolved in effluent unless otherwise stated).

(2) Legal systems for environmental control in Japan, Japan Iron and Steel Foundation, May 29, 1986.

(3) Kanagawa Prefectural Regulations, December 1970.

(4) Taiwan Water Pollution Control Act referenced in "Environmental control status in China Steel Corporation" 1989.

(5) Variances may be allowed during periods of excess run-off.

(6) Bioassay on salmonoid species.

(7) Dissolved in effluent passing through a 3 μm filter.

(8) Natural background concentration will be assessed.

TABLE A 1.1.4 **SUMMARY OF INTERNATIONAL EFFLUENT DISCHARGE STANDARDS**
(Selected Effluent Parameters [mg/L])

Parameter	Sweden Coke (NSPS) Reg.	CSC Final Actual	ROC Final Reg.	Japan Final (NSPS) Reg.	Germany Coke Reg.	Korea Final Reg.	Stelco Final Actual
TSS	5(5)	27.8	<200	<200(70)	<50	100	4.8
COD	-	99	<300	<120(25)	<200	100	98
Oil	-	1	<10	<5(5)	-	-	7.6
Phenol	3(1)	0.25	<5	<5(0.5)	0.5(1988) <1	-	0.02
N(NH_4)	-(100)	173	-	-	80(1988)	-	0.21
CN^-	2(1)	0.54	<1	-(1.0)	0.1(1988) <0.5	-	0.039
CR^{VI}	-	0.4	<0.5	<2(0.5) (1989)	-	0.05	0.009

Sweden	(1995)	Phenol	0.05 g/tonne
		PAH	0.2 g/tonne
		CN^-	1 mg/litre
		TSS	20 g/tonne

NOTES:	NSPS	New Source Performance Standards
	CSC	China Steel Corporation, Taiwan
	ROC	Republic of China (Taiwan)
	Stelco	Stelco steel plant, Nanticoke, Ontario

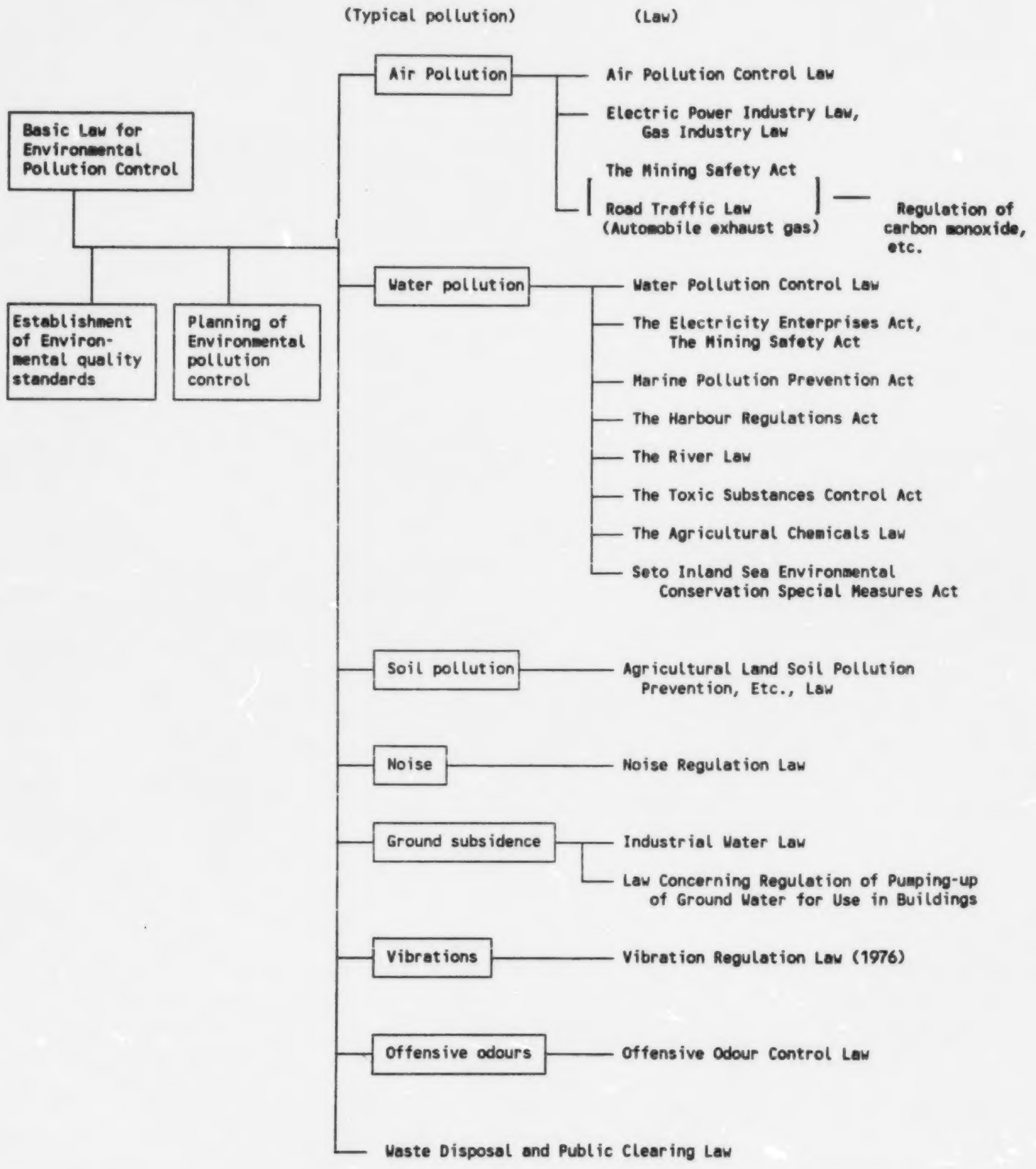
A 2.0 JAPAN

Japan applies the provision of its legal system, as represented in Figure A 2.1, for the control of air emissions. It is important to note the evolutionary nature of the standards and the need to identify the latest amendments. For example, particulate emissions for coke ovens of 100 mg/Nm^3 in 1982 are now more restrictive (ca. 50 mg/Nm^3). Similarly, allowable phenol concentrations in wastewater were 5 mg/L (standards obtained in May 1989) but are now 0.5 mg/L in the Water Pollution Prevention Act. In addition, more stringent requirements can be applied by the Prefectures and in some cases more stringent specific requirements may be imposed on specific plants through Pollution Prevention Agreements.

The following tables and figures summarize the Japanese approach and requirements for steel plant environmental control.

Figure A 2.1	Legal System for Environmental Control (Japan)
Table A 2.1	National Environmental Quality Standards (Japan)
Table A 2.2	Emission Standards (Japan) - Sulfur Oxides
Table A 2.3	Emission Standards (Japan) - Soot and Dust
Table A 2.4	Emission Standards (Japan) - Nitrogen Oxides
Table A 2.5	Emission Standards (Japan) - Effluent
Table A 2.6	Environmental Quality Standards for Noise (Japan)
Table A 2.7	Water Pollution Prevention Act (Japan) - applied to the Oshigima works
Table A 2.8	Kanagawa Prefectural Regulation (Japan) - applied to the Oshigima works
Table A 2.9	Pollution Prevention Agreement (Japan) - applied to the Oshigima works
Table A 2.10	Final Effluent Standards - Japan

FIGURE A 2.1 LEGAL SYSTEM FOR ENVIRONMENTAL CONTROL (JAPAN)


(Typical pollution)
(Law)
Basic Law for Environmental Pollution Control
Establishment of Environmental quality standards
Planning of Environmental pollution control
Air Pollution
Air Pollution Control Law
Electric Power Industry Law, Gas Industry Law
The Mining Safety Act
Road Traffic Law (Automobile exhaust gas)
Regulation of carbon monoxide, etc.
Water pollution
Water Pollution Control Law
The Electricity Enterprises Act, The Mining Safety Act
Marine Pollution Prevention Act
The Harbour Regulations Act
The River Law
The Toxic Substances Control Act
The Agricultural Chemicals Law
Seto Inland Sea Environmental Conservation Special Measures Act
Soil pollution
Agricultural Land Soil Pollution Prevention, Etc., Law
Noise
Noise Regulation Law
Ground subsidence
Industrial Water Law
Law Concerning Regulation of Pumping-up of Ground Water for Use in Buildings
Vibrations
Vibration Regulation Law (1976)
Offensive odours
Offensive Odour Control Law
Waste Disposal and Public Clearing Law

Source: "Industry and Pollution:, Industrial Location and Environmental Protection Bureau of Ministry of International Trade and Industry (1974)

TABLE A 2.1 NATIONAL ENVIRONMENTAL QUALITY STANDARDS (JAPAN)

(1) Ambient Air Quality Standards

Sulfur Dioxide, Carbon Monoxide, Suspended Particulate Matter, Nitrogen Dioxide, Photochemical Oxidants

Substance	Sulfur dioxide	Carbon monoxide	Suspended[1] particulate matter	Nitrogen[2] dioxide	Photochemical[3] oxidants
Environmental conditions	Daily average of hourly values shall not exceed 0.04 ppm and hourly values shall not exceed 0.1 ppm.	Daily average of hourly values shall not exceed 10 ppm and average of hourly values in eight consecutive hours shall not exceed 20 ppm.	Daily average of hourly values shall not exceed 0.10 mg/m^3 and hourly values shall not exceed 0.20 mg/m^3.	Daily average of hourly values shall be within the range between 0.04 ppm and 0.06 ppm or below.	Hourly values shall not exceed 0.06 ppm.
Measuring methods	Conductometric method	Nondispersive infrared analizer method	Weight concentration measuring methods based on filtration collection, or light scattering method, or piezoelectric microbalance method, or B-ray attenuation method yielding values having a linear relation with the values of the above method.	Colorimetry employing Saltsman reagent (with Saltzman's coefficient being 0.84).	Absorptiometry using neutral potassium iodide solution or coulometry.

Notes: 1. Suspended particulate matter shall mean airborne particles of 10 microns or less in diameter.

2. a) In an area where the daily average of hourly values exceeds 0.06 ppm, efforts should be made to achieve the level of 0.06 ppm by 1985.

b) In an area where the daily average of hourly values is within the range between 0.04 ppm and 0.06 ppm, efforts should be made so that the ambient concentration be maintained around the present level within the range or not significantly exceed the present level.

3. Photochemical oxidants are oxidizing substances such as ozone and peroxiacetyl nitrate produced by photochemical reactions (only those capable of isolating iodine from neutral potassium iodide, excluding nitrogen dioxide).

TABLE A 2.1 (continued) **NATIONAL ENVIRONMENTAL QUALITY STANDARDS (JAPAN)**

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(2) Standards relating to Living Environment

a. Rivers

Category	Item Purpose of utilization	Standard values Biochemical oxygen demand (BOD)	Standard values Dissolved oxygen (DO)
AA	Water supply, class 1; conservation of natural environment and uses listed in A-E	1 mg/ℓ or less	7.5 mg/ℓ or more
A	Water supply, class 2; fishery, class 1; bathing and uses listed in B-E	2 mg/ℓ or less	7.5 mg/ℓ or more
B	Water supply, class 3; fishery, class 2 and uses listed in C-E	3 mg/ℓ or less	5 mg/ℓ or more
C	Fishery, class 3; industrial water, class 1 and uses listed in D-E	5 mg/ℓ or less	5 mg/ℓ or more
D	Industrial water, class 2; agricultural water and uses listed in E	8 mg/ℓ or less	2 mg/ℓ or more
E	Industrial water, class 3; conservation of environment	10 mg/ℓ or less	2 mg/ℓ or more

TABLE A 2.1 (continued) NATIONAL ENVIRONMENTAL QUALITY STANDARDS (JAPAN)

(2) Standards relating to Living Environment

b. Coastal waters

Cattgory	Item	Standard values	Standard values
	Purpose of utilization	Biochemical oxygen demand (BOD)	Dissolved oxygen (DO)
A	Fishery, class 1; bathing; conservation of natural environment and uses listed in B-C	2 mg/ℓ or less	7.5 mg/ℓ or more
B	Fishery, class 2; industrial water and uses listed in C	3 mg/ℓ or less	5 mg/ℓ or more
C	Conservation of environment	8 mg/ℓ or less	2 mg/ℓ or more

TABLE A 2.1 (continued) **NATIONAL ENVIRONMENTAL QUALITY STANDARDS (JAPAN)**

(2) Standards relating to Living Environment

c. Lakes

Category	Item Purpose of utilization	Standard values Biochemical oxygen demand (BOD)	Standard values Dissolved oxygen (DO)
AA	Water supply, class 1; fishery, class 1; conservation of natural environment and uses listed in A-C	1 mg/ℓ or less	7.5 mg/ℓ or more
A	Water supply, classes 2 and 3; fishery, class 2; bathing and uses listed in B-C	3 mg/ℓ or less	7.5 mg/ℓ or more
B	Fishery, class 3; industrial water, class 1; agricultural water and uses listed in D-E	5 mg/ℓ or less	5 mg/ℓ or more
C	Industrial water, class 2; conservation of environment	8 mg/ℓ or less	2 mg/ℓ or more

Source: Quality of the Environment in Japan 1983
Environment Agency Government of Japan

TABLE A 2.2 EMISSION STANDARDS (JAPAN) - SULFUR OXIDES

(1) Sulfur Oxides (latest revision, Sept. 28, 1976)

a. Sulfur oxide emission standard

The emission standard for sulfur oxides which applies at a given sulfur oxides emitting facility may be calculated by inserting a value (K), specified under Cabinet Order for the region in which the facility is located, into the following equation:

$$q = K \times 10^{-3} \times He^2$$

Here q is the hourly volume of sulfur oxides emitted (in unit of Nm^3) and He, effective height of stack, is the sum of actual height of stack and smoke ascent height. The size of K, which varies according to the region, inversely determines the degree of regulation, for the effect of a reduction in K is a much stiffer control standard. The standard for sulfur oxides has hence been labelled the "K-value regulation".

The general emission standard for sulfur oxides (the K value) was strengthened on September 28, 1976, and as a result all of Japan is now controlled under sixteen K ranks ranging from 3.00 to 17.5.

b. Regulation on fuel

The regulation on fuel quality under the Article 15 of the Air Pollution Control Law was revised in September 1976. Asahikawa was added to the previous list of 14 areas (Tokyo, Osaka, etc.).

The regulation standards were upgraded to a sulfur content ranging from 0.5 to 1.2%.

Source: The Japan Iron and Steel Federation, May 29, 1989

TABLE A 2.2 (continued) EMISSION STANDARDS (JAPAN) - SULFUR OXIDES

Regulation on sulfur oxides emission (K value)

(a) General Standards

Area			K value
1	6 areas:	Central Tokyo, Yokohama-Kawasaki, Nagoya, Yokkaichi, Osaka-Sakai, Kobe-Amagasaki	3.0
2	21 areas:	Chiba, Fuji, Kyoto, Ilimeji, Mizushima, Kitakyushu and others	3.5
3	1 area:	Sapporo	4.0
4	4 areas:	Hitachi, Kashima and others	4.5
5	3 areas:	Toyama-Takaoka, Kure, Toh-yo	5.0
6	9 areas:	Annaka, Niigata, Okayama, Shimonoseki and others	6.0
7	3 areas:	Tomakomai, Hachioji, Kasaoka	6.42
8	6 areas:	Sendai, Fukui, Iliroshima and others	7.0
9	8 areas:	Asahikawa, Utsunomiya, Mihara, Tokushima and others	8.0
10	8 areas:	Asahikawa, Utsunomiya, Mihara, Tokushima and others	8.76
11	6 areas:	Takasaki, Urawa, Narita, Naha and others	9.0
12	4 areas:	Shizuoka, Sasebo, and others	10.0
13	15 areas:	Hakodate, Gifu, Takamatsu, Minamata and others	11.5
14	6 areas:	Mishima, Kurume and others	13.0
15	20 areas:	Aomori, Morioka, Yamagata, Nagamo, Kagoshima and others	14.5
16	Others		17.5

TABLE A 2.2 (continued) EMISSION STANDARDS (JAPAN) - SULFUR OXIDES

Regulation on sulfur oxides emission (K value)

(a) Special Standards

Area		K value
6 areas:	Central	1.17
8 areas:	Chiba, Fuji, Himeji, Mizushima, Kitayushu and others	1.75
14 areas:	Kashima, Toyama, Kyoto, Fukuyama, Ohmuta, Ohita and others	1.34

Note: Special standards are applied to newly constructed facilities only.

TABLE A 2.3 EMISSION STANDARDS (JAPAN) - SOOT AND DUST

(2) Soot and Dust (Latest amendment, May 1982)

(Unit: g/Nm^3)

Nature of facility (excerpt)	Ordinary emission standard		Special emission standard	
	Large scale	Small scale	Large scale	Small scale
Boilers (using gas)	0.05	0.10	0.03	0.05
Boilers (using oil)	0.10-0.15	0.25-0.30	0.04-0.05	0.15-0.15
Boilers (using coal)	0.10 | 0.20 | 0.30		0.05 | 0.10 | 0.15	
Gas generating furnace	0.05		0.03	
Blast furnace	0.05		0.03	
Cement kiln	0.10		0.05	
Waste incinerator	0.15	0.50	0.08	0.15
Coke oven	0.15		0.10	

Notes:
1. Prefectures may, by decree, set more stringent standards.
2. The gas emission rate of 40,000 Nm^3/h is the criterion used for scale classification. However, heavy oil boilers and coal boilers are classified into four and three scales respectively. The criteria for the former are 200,000 Nm^3/h, 40,000 Nm^3/h and 10,000 Nm^3/h, and 200,000 Nm^3/h and 40,000 Nm^3/h are for the latter.

TABLE A 2.4 EMISSION STANDARDS (JAPAN) - NITROGEN OXIDES

(3) Nitrogen Oxides (as of August 2, 1979) (Abstract)

Type of facility	Stack gas volume (Unit: 1,000Nm³/h)	Date of instal-ling / O_2 (%)	Standard value (ppm)				
			Before Aug. 9, 1973	after Aug. 10, 1973 before Dec. 9, 1975	after Dec. 10, 1975 before June 15, 1977	after June 18, 1977 before Aug. 9, 1977	after Aug. 10, 1979
Boiler (Gas firing)	500 and above	5	130	130	100	60	60
	100 - 500		130	130	100	100	100
	40 - 100		130	130	130	100	100
	10 - 40		150	150	130	130	130
	5 - 10		150	150	150	150	150
	less than 5		from Aug 10, 1984: 150	from Aug 10, 1984: 150	from Aug 10, 1984: 150	150	150
Boiler (Coal firing)	100 and above	6	480	480	480	400	400
	40 - 100		480	480	480	400	400
	10 - 40		480	480	480	400	400
	5 - 10		480	480	480	400	400
	less than 5		from Aug. 10, 1984: 480	from Aug. 10, 1984: 480	from Aug. 10, 1984: 480	400	400
Boiler (Solid material firing excluding coal)	100 and above	6	480	480	480	400	400
	40 - 100		480	480	480	400	400
	10 - 40		480	480	480	400	400
	5 - 10		480	480	480	400	400
	less than 5		from Aug. 10, 1984: 480	from Aug. 10, 1984: 480	from Aug. 10, 1984: 480	400	400
Boiler (Liquid firing)	500 and above	4	180	180	150	130	130
	100 - 500		190	180	150	150	150
	40 - 100		190	180	150	150	150
	10 - 40		230	230	150	150	150
	5 - 10		250	250	250	180	180
	less than 5		from Aug. 10, 1984: 250	from Aug. 10, 1984: 250	from Aug. 10, 1984: 250	180	180
Sintering furnace (excluding pellet baking furnace)	100 and above	15	260	260	260	220	220
	10 - 100		270	270	270	220	220
	less than 10		300	300	300	300	220
Calcination furnace		10	200	200	200	200	200
Roasting furnace		14	250	250	250	250	220
Blast furnace		15	120	120	120	120	100
Metal melting furnace		12	200	200	200	200	180

TABLE A 2.4 (continued) EMISSION STANDARDS (JAPAN) - NITROGEN OXIDES

(3) Nitrogen Oxides (as of August 2, 1979) (Abstract)

Type of facility	Stack gas volume (Unit: 1,000 Nm^3/h)	Date of instal-ling / O_2 (%)	Standard value (ppm)				
			Before Aug. 9, 1973	after Aug. 10, 1973 before Dec. 9, 1975	after Dec. 10, 1975 before June 15, 1977	after June 18, 1977 before Aug. 9, 1977	after Aug. 10, 1979
Metal heating furnace	100 and above	11	160		100		
	40 - 100		170		150	130	
	10 - 40						
	5 - 10					150	
	less than 5		200			180	
Petroleum heating furnace	40 and above	6	170		100		
	10 - 40		180		150	130	
	5 - 10			180		150	
	less than 5		200			180	
Cement calcination furnace (excluding wet types)	100 and above	10	480		250		
	less than 100					350	
Baking furnace used for manufacturing refractories and fire bricks		18	450				400
Melting furnace used for manufacturing plate glasses and glass fibers		15	400				360
Drying furnace		16	250				230
Waste incinerator (continuous type)	40 and above	12	300			250	
	less than 40						
Nitric acid production facility		Os	200				
Coke oven (excluding Otto type)	100 and above	7	350		200	170	
	less than 100						

Notes: 1. Reference to Unit, the symbol "-" means "and above/less than": e.g. a - b mean a and above/less than b.

2. The NO_x emission concentration shall be converted through the following equation. (Except in the case of nitric acid production facilities.)

$$C = \frac{21 - O_n}{21 - O_s} C_s$$

C: Nitrogen oxides emission concentration

O_n: Oxygen concentration in flue gas (set values in the above tables)

O_s: Actual oxygen concentration in flue gas

C_s: Actual nitrogen oxides emission concentration

TABLE A 2.5 **EMISSION STANDARDS (JAPAN) - EFFLUENT**

(4) Effluent Standards (June 21, 1971; Amendments 1974, 1975)

Item	Permissible limits
pH	5.8 ~ 8.6 for effluent discharged into public water bodies other than coastal waters 5.0 ~ 9.0 for effluent discharged into costal waters
BOD, COD	160 mg/ℓ (daily average 120 mg/ℓ)
SS	200 mg/ℓ (daily average 150 mg/ℓ)
N-hexane extracts	5 mg/ℓ (mineral oil) 30 mg/ℓ (animal and vegetable fats)
Phenols	5 mg/ℓ
Copper	3 mg/ℓ
Zinc	5 mg/ℓ
Dissolved iron	10 mg/ℓ
Dissolved manganese	10 mg/ℓ
Chrome	2 mg/ℓ
Fluorine	15 mg/ℓ
Number of coliform groups (per cc)	3,000 (daily average)

Notes: 1. Prefectures may, by decree, set more stringent standards.

2. The discharge standards in this table are applied to the effluents from industrial plants and other places of business whose volume of effluents per day is not less than 50 m^3.

3. The discharge standards for BOD are applied to public waters other than coastal waters and lakes, while the discharge standards for COD are applied only to effluents discharged into costal waters and lakes.

Source: Quality of the Environment in Japan 1983
Environmental Agency Government of Japan

TABLE A 2.6 ENVIRONMENTAL QUALITY STANDARDS FOR NOISE (JAPAN)

a. Environmental quality standards

Area Type	Time Category			Applicable Areas
	Day time	Morning Evening	Night time	
AA	45 dB(A)	40 dB(A)	35 dB(A)	Areas designated for each classification of land areas by a prefectural governor based on the provision of Article 2 of the Cabinet Order Relating to the Delegation of Authority to Designate Water and Land Areas for Environmental Quality Standards (Cabinet Order No. 159 of 1971)
A	50 dB(A)	45 dB(A)	40 dB(A)	
B	60 dB(A)	55 dB(A)	50 dB(A)	

NOTES:

1. Areas coming within the AA category are areas where quiet is specially required such as where there is a concentration of convalescent facilities.
2. Areas coming within the A category are areas which are used mainly for residential purposes.
3. Areas coming within the B category are areas which are used considerably for residential purposes and which are also used for commercial and industrial purposes.

b. Environmental quality standards for noise on boundary line

Area type	Time Category			Applicable area
	Day time	Morning Evening	Night time	
No. 1	45dB(A) ~50dB(A)	40dB(A) ~45dB(A)	40dB(A) ~45dB(A)	Areas where quiet is specially required for the preservation of good residential conditions.
No. 2	50dB(A) ~60dB(A)	45dB(A) ~50dB(A)	40dB(A) ~50dB(A)	Areas where quiet is required, because they are used mainly for residential purposes.
No. 3	60dB(A) ~65dB(A)	55dB(A) ~65dB(A)	50dB(A) ~55dB(A)	Areas which are used not only for residential purposes but also for commercial and industrial purposes.
No. 4	65dB(A) ~70dB(A)	60dB(A) ~70dB(A)	55dB(A) ~65dB(A)	Areas which are used mainly for industrial purposes.

NOTES: Factories and other work sites that are located within the designated areas and equipped with the facilities by Cabinet Order are subject to regulations on noise (hereinafter referred to as "specified factories, etc.").

Prefectural governors set the regulatory standards which the specified factories, etc. are under obligation to serve in obedience with the Notification issued by the Environmental Agency.

TABLE A 2.7 **Regulation figures for wastewater according to the Water Pollution Prevention Act (Japan) (as applied to the Oshigima works of NKK).**

		Sea area [wastewater flows in]		
		Maximum [density allowed]		
		New plants	Existing plants	
	pH (potential of hydrogen)	5.8	8.6	
DENSITY (mg per liter)	BOD	160	160	JANUARY 1989
	COD	25	60	
	SS	70	90	
	Oil content: mineral	5	5	
	" : animal & vegetable	5	10	
	Phenol	0.5	0.5	
	Copper	1	1	
	Zinc	1	3	
	Soluble iron	3	10	
	Soluble manganese	10	10	
	Chrome	2	2	
	Nickel			
	Fluorine	15	15	
	Cadmium	0.1	0.1	
	Cyan	1	1	
	Organic Phosphorus	1	1	
	Lead	1	1	
	Hexavalent chrome	0.5	0.5	
	Arsenic	0.5	0.5	
	Mercury	0.005	0.005	
	Alkyl silver	No amount shall be detected.		
	PCB	0.003	0.003	
	Tricholoro ethylene	0.3	0.3	
	Tetrachloro ethylene	0.1	0.1	

Colon bacilli	3,000 bacilli per cubic centimeter
Wastewater discharged:	73,910 cubic meters per day (Ogishima plus existing Kawasaki plants) + 340 cubic meters per day (Tsurumi River) = 74,250 cubic meters (excluding indirectly related water)
COD in total:	3,029.4 kg per day (Ogishima plus existing Kawasaki plants) + 10.8 kg (Tsurumi River) = 3,040.2 kg per day
Appearance:	
Odor:	
Promulgated:	December 25, 1970

TABLE A 2.8 **Regulation figures for wastewater according to the Kanagawa Prefectural Regulation (Japan) (as applied to the Oshigima works of NKK).**

		Sea area [wastewater flows in]	
		Maximum [density allowed]	
		New plants	Existing plants
	pH (potential of hydrogen)	5.8	8.6
(DENSITY (mg per liter))	BOD	25	60
	COD	25	60
	SS	70	90
	Oil content: mineral	5	5
	" : animal & vegetable	5	10
	Phenol	0.5	0.5
	Copper	1	3
	Zinc	1	3
	Soluble iron	3	10
	Soluble manganese	1	1
	Chrome	2	2
	Nickel	1	1
	Fluorine	15	15
	Cadmium	0.1	0.1
	Cyan	1	1
	Organic Phosphorus	0.2	0.2
	Lead	1	1
	Hexavalent chrome	0.5	0.5
	Arsenic	0.5	0.5
	Mercury	0.005	
	Alkyl silver	No amount shall be detected.	
	PCB	0.003	0.003
	Tricholoro ethylene		
	Tetrachloro ethylene		0.1

Colon bacilli	3,000 bacilli per cubic centimeter
Wastewater discharged:	73,910 cubic meters per day (Ogishima plus existing Kawasaki plants) + 340 cubic meters per day (Tsurumi River) = 74,250 cubic meters (excluding indirectly related water)
COD in total:	3,029.4 kg per day (Ogishima plus existing Kawasaki plants) + 10.8 kg (Tsurumi River) = 3,040.2 kg per day
Appearance:	No color or turbidity shall appear.
Odor:	No odor shall be detected.
Promulgated:	March 12, 1971

TABLE A 2.9 **Regulation figures for wastewater according to the Pollution Prevention Agreement (Japan) (as applied to the Oshigima works of NKK).**

		Maximum [density allowed]			
		Ogishima		Mizue Ikegami Toda	Ogimachi Tsurumi River
		E & W	South		
	pH				
	BOD				
DENSITY (mg per liter)	COD	23	20	30	25
	SS	30	30	40	35
	Oil content: mineral	3	3	4	4
	" : animal & vegetable				
	Phenol	0.5	0.5	0.5	0.5 (1)
	Copper				
	Zinc	1	1	3	3
	Soluble iron	3	3	5	5
	Soluble manganese	1	1	1	1
	Chrome	1	1	1	1 (2)
	Nickel				
	Fluorine				
	Cadmium				
	Cyan	1	1	1	1 (3)
	Organic Phosphorus				
	Lead				
	Hexavalent chrome	0.5	0.5	0.5	0.5 (4)
	Arsenic				
	Mercury				
	Alkyl silver				
	PCB				
	Tricholoro ethylene				
	Tetrachloro ethylene				

Wastewater discharged at east Plant, Ogishima:	23,140 m^3/day
west Plant, Ogishima:	17,120 m^3/day
south Plant, Ogishima:	500 m^3/day
by population of Nizue:	20,140 m^3/day
" Ikegami:	12,450 m^3/day
" Ogimachi:	6,400 m^3/day
" Toda:	10,950 m^3/day
" Tsurumi:	1,900 m^3/day
Tsurumi River:	600 m^3/day
Total:	93,200 m^3/day

Agreement signed: December 25, 1970

TABLE A 2.9 (continued) **Regulation figures for wastewater according to the Pollution Prevention Agreement (Japan) (as applied to the Oshigima works of NKK).**

Note:

(1) indicates density at scupper of water-purifying facility

(2) at scupper of processing facility

(3) at scupper of water-purifying facility

(4) at scupper of processing facility

Other remarks: Kawasaki Prefectural Regulation: degree of turbidity shall be less than 12 degrees or less than 8 degrees in case of dilution with water at 1:1 ratio. Temperature: less than 38 degrees C, and difference with sea area shall be less than 10 degrees C.

Administrative guidance: efforts shall be made for reducing phosphorous and nitrogen; trichloro ethane to 3 mg/liter; carbon tetra-chloride to 0.03 mg/liter.

TABLE A 2.10 FINAL EFFLUENT STANDARDS - JAPAN (mg/L)

Parameter	Published	National		Prefecture		Local
		New Plant	Old Plant	New Plant	Old Plant	
TSS	<200.0	70.0	90.0	70.0	90.0	30-40
Oil Content	<5.0	5.0	15.0	5.0	15.0	3-4.5
Phenol	<5.0	0.5	0.5	0.5	0.5	0.5
Ammonia	---	---	---	---	---	---
Cyanide	1.0	1.0	1.0	1.0	1.0	1.0
Chromium	<2.0					
Chromium (Cr^{VI})		0.5	0.5	0.5	0.5	0.5
Lead	1.0	1.0	1.0	1.0	1.0	---
Zinc	5.0	1.0	3.0	1.0	3.0	1-11
pH (units)	5.8	5.8	8.6	5.8	8.6	---

A 3.0 SWEDEN

Sweden is another jurisdiction where the standards applied to the iron and steel industry take into consideration a number of factors, including:

(1) Site specific regulations.
(2) Focus on hazardous (LAER) substances.
(3) Evolutionary standards.
(4) Focus on total mass of pollutants imposed on the environment.

A summary of the current Swedish experience is contained in Table 3.1 and further improvements are contained in Table 3.2. These tables illustrate the evolutionary Swedish approach and the emphasis on the use of the total mass per tonne approach.

Swedish standards, termed conditions, are contained in Tables 3.3 to 3.5 as they apply to the two basic steel plants. Note that both Plants A and B are located on the Baltic Sea and have marine discharges.

TABLE A 3.1 SUMMARY OF CURRENT SWEDISH EXPERIENCE

Two Integrated Iron and Steel Plants
"Plants A and B" Total Production 2.6 M Tonnes

I. COKE PLANT - EFFLUENT

TSS	50 g/tonne coke
adsorbed PAH	0.2 g/tonne coke
ammonia	200 - 700 g/tonne coke

II. COKE PLANT - EMISSIONS

Atmospheric PAH	5 - 10 g/tonne
2/3 from ejection	
1/3 from quenching	
mercury	50 kg/year/plant (from coal loading)

III. SINTER PLANT - EMISSIONS

particulate	0.7 kg/tonne

<10 mg/Nm^3 recommended for modern fabric filters>

IV. BLAST FURNACE BLOWDOWN - EFFLUENT

TSS	3 - 30 g/tonne steel
Zn	1 - 10 g/tonne steel
Pb	1 - 0.4 g/tonne steel

V. STEEL MAKING - CHARGING AND TAPPING - EMISSIONS

BLAST FURNACE

particulate	0.1 - 0.25 kg/tonne steel
TCDD equivalent	0.001 ng/m^3

ELECTRIC ARC FURNACES

particulate	0.1 - 0.9 kg/tonne steel (mostly fugitive)
TCDD equivalent	0.1 - 5 ng/m^3 (0.2 - 10 ρg/tonne)

Scrap produces emissions of cadmium and mercury in EAF

Cd	0.4 - 0.6 g/tonne
Hg	0.3 - 0.6 g/tonne

TABLE A 3.1 (continued) SUMMARY OF CURRENT SWEDISH EXPERIENCE

VI. BOF CONVERTERS - EMISSIONS	
• particulate	0.3 kg/tonne steel (includes ladle metallurgy). <Use "dog houses" as local fume collection approach>.
• TCDD equivalent	0.002 ng/m^3
VII. HOT FINISHING, CONTINUOUS CASTING - EFFLUENT	
• Oil	5 mg/L (25 g/tonne)
VII. COLD FINISHING - EFFLUENT	
Pickling effluent	(neutralization, flocculation and sedimentation)
• Cr^{VI}	0.1 mg/L
• Zn, Fe	2 mg/L

Further Improvements:

(1) Modern Fabric Filters:

Collection can be made to 1 mg/Nm^3 and 10 mg/Nm^3 should be considered readily attainable (BACT).

(2) Scrap Contamination - PAH and TCDD:

The chlorinated oils, emulsions and PVCs on scrap produces both dioxins and PAH. TCDD equivalent is calculated to be 0.1 - 3 g per EAF plant (12 plants in Sweden). Demands for reduction to 0.3 g/plant are being made in two cases. A research program to limit TCDD technically and economically is under way. NOTE: This may also be a factor in BOF scrap.

TABLE A 3.2 **SWEDISH STANDARDS**

Present conditions for the Swedish integrated steel plants

Some of the present conditions for the two Swedish steel plants (both located on the Baltic Sea) are presented in this table. The Swedish Franchise Board will set new conditions for plant B in 1990.

Plant A conditions concerning discharges into the sea:

	TSS	Oil	CN	Phenol	NH_3	H_2S
Blast furnace			4 kg/d	2 kg/d		
Hot rolling and Continuous casting	5 mg/L*	3 mg/L*				
Coke plant			2 g/m^3	3 g/m^3	1800 g/m^3	0.1 g/m^3

* max. 500 m^3 water/h

Plant A conditions concerning emissions into the air:

	Dust
Sintering plant	50 mg/m^3(ndg)
Blast furnace	0.3 kg/ton steel
BOF-converter	0.35 kg/ton steel

Plant B conditions concerning discharges into the sea:

Blast furnace	Recirculation of at least 95% of the cooling water
Converter	TSS 15 kg/d
Hot rolling	TSS 10 kg/d Oil 5 kg/d
From settling pond	TSS 25 mg/L

TABLE A 3.2 (continued) **SWEDISH STANDARDS**
Present conditions for the Swedish integrated steel plants

Plant B conditions concerning emissions into the air:

	Dust	
Sintering plant	1	kg/ton sinter
Blast furnace	0.3	kg/ton steel
BOF-converter	0.3	kg/ton steel

TABLE A 3.3 **SWEDISH STANDARDS**
Swedish Franchise Board - proposed new conditions for plant B in 1990.

- The total dust emissions from blast furnaces may not exceed 0.10 kg/tonne produced steel.

- Secondary gases from the blast furnace and gases from the filling shall be cleaned in fabric filters. The dust concentration after cleaning may not exceed 10 mg/m^3 (ndg).

- Water from scrubber for primary blast furnace gases shall be cleaned by sand filters and the discharges of pollutants may not exceed the following concentrations:

Zn	0.5 mg/L
Pb	0.2 mg/L
CN total	1.0 mg/L
CN free	0.1 mg/L
Total suspended solids	10.0 mg/L
pH	<8.0

- The process gases from the sintering plant shall be cleaned from sulphuric compounds from 1992.

- The process gases from the sintering plant shall be cleaned from dust by fabric filters from 1991. The dust concentration after cleaning may not exceed 10 mg/m^3 (ndg).

- The total dust emission from the sintering plant may not exceed 0.15 kg/tonne produced sinter from 1991.

TABLE A 3.3 (continued) **SWEDISH STANDARDS**
Swedish Franchise Board - proposed new conditions for plant B in 1990.

- The process gases from the basic oxygen furnaces (BOF) shall be cleaned in scrubbers with a maximum concentration of 50 mg/m^3 (ndg).

- Other gases from smelting and refining shall be cleaned in fabric filters with a maximum concentration of 10 mg/m^3 (ndg) in the cleaned gases.

- The total emissions, including fugitive emission, of dust from melting and refining may not exceed 0.1 kg/tonne produced steel.

- The concentration of pollutants in water from the scrubber for primary BOF-gases may not exceed:

Zn	0.5 mg/L
Pb	0.2 mg/L
Total suspended solids	1 kg/day

- Gases from operations in the hot rolling mill shall be cleaned in fabric filters with a maximum concentration of 10 mg/m^3 (ndg) in the cleaned gases.

- The primary cooling water in the rolling mill shall be recirculated to 100%.

- Dry quenching shall be introduced in the coke plant before 1992.

- The discharges to water from the coke plant may not exceed the following limits after biological treatment:

NH_3	100 mg/L
Phenol	1 mg/L
CN	1 mg/L
Total suspended solids	5 mg/L

- Metals in slag, sludge, dust, etc., should be recycled as much as is possible.

TABLE A 3.4 SWEDISH PROPOSALS TO THE BALTIC MARINE COMMISSION CONCERNING RESTRICTIONS OF DISCHARGES FROM IRON AND STEEL INDUSTRY

Sweden proposes that the following target values in g/tonne per unit produced for discharges to water for 1995 should be used.

	TSS	Oil	Zn	Pb	CN	Phenol	PAH
Blast furnace	10	-	1	0.1	-	-	-
Converter	5	-	-	-	-	-	-
Continuous casting	10	5	-	-	-	-	-
Hot rolling	50	10	-	-	-	-	-
Cold rolling	50	10	-	-	-	-	-
Coke plant	20	-	-	-	*	0.05	0.2

* The total cyanide concentration in discharges to the recipient should not exceed 1 mg/L.

Sweden also proposes that the following recommendations should be added and come into force in 1995:

- Coke plants: Steam-stripping of the wastewater to reduce ammonia and other gases. Reduction of fixed ammonia by e.g. evaporation at high pH. Biological treatment of the wastewater to reduce carbonaceous and nitrogenous compounds.
- Cooling water from hot rolling, converters and continuous casting machines should be recirculated at least 90%.
- All wastewater, including storm water, containing suspended particles should pass settling ponds before it is discharged to the receiving water.
- Before 1990 all not regenerated pickling acids and rinsing water should be neutralized and then treated in order to minimize the metal content. Before 1995 regeneration of pickling acids should be introduced at all the steel plants where pickling acids are used.

TABLE A 3.4 (continued) SWEDISH PROPOSALS TO THE BALTIC MARINE COMMISSION CONCERNING RESTRICTIONS OF DISCHARGES FROM IRON AND STEEL INDUSTRY

- Discharges of metals from pickling and plating plants should be limited as follows:

	Maximum concentration (mg/L)
Ni	1
Cr - total	1
Cr^{VI}	0.1
Zn	2
Cd	0.1

TABLE A 3.5 SWEDISH PROPOSALS CONCERNING EMISSIONS FROM THE IRON AND STEEL INDUSTRY

Sweden proposes that the following emission restrictions be used:

1. As of January 1st 1995 dust emissions from processes * in the iron and steel industry should be avoided or collected and filtered before being allowed to enter the atmosphere.

   * Examples of processes:

   - coke plants
   - sintering plants
   - blast furnaces
   - basic oxygen furnaces
   - electric arc furnaces
   - casting
   - rolling, furnaces in rolling mills
   - cutting

2. Fugitive emissions from all processes have to be avoided as far as technically feasible, e.g. by encapsulation, evacuation hoods or good housekeeping practices.

TABLE A 3.5 (continued) **SWEDISH PROPOSALS CONCERNING EMISSIONS FROM THE IRON AND STEEL INDUSTRY**

3.a) Fabric filters can be used for dust cleaning in many processes, e.g. in sintering plants, for secondary gases from blast furnaces and basic oxygen furnaces, in electric arc furnaces, at grinding operations, etc.

Fabric filters should preferably be used in these processes. When fabric filters are used the particulate matter content of the filtered gases should, as a guiding value, not exceed 10 mg/m^3 (ndg).

3.b) In any case the particulate matter content of the filtered gases should not exceed 50 mg/m^3 (ndg).

4.a) Low emission coke cooling techniques, preferably dry quenching, should be used for new installations and from 1995 for existing coke plants. Dust emissions in the waste gas from dry quenching should not exceed 20 mg/m^3 (ndg). The total dust emissions from wet quenching may not exceed 20 g per tonne of coke.

4.b) Filling gases from coke oven pushing shall be captured and conveyed to a dust collector. Dust emission shall not exceed 5 g per tonne of coke.

5.a) As of January 1st 1992 the total emissions (fugitive emissions from charging and tapping and filtered gas) from all processes should be measured and reported.

5.b) Dust emissions shall be continuously monitored if the particulate is 5 kg/h or more or the cadmium emission is 5 g/h or more.

Installations with a particulate emission of 2 to 5 kg/h shall be equipped with measuring instruments which continuously determine waste gas opacity, e.g. optical transmission.

TABLE A 3.5 (continued) SWEDISH PROPOSALS CONCERNING EMISSIONS FROM THE IRON AND STEEL INDUSTRY

6. The possibilities of further reducing emissions from iron and steel production shall be investigated. Emissions should be determined and reported regularly. Examples of pollutants of special interest are:

- NO_x e.g. sintering plants, furnaces and pickling
- PAH from e.g. coke plants
- Dioxins from e.g. electric arc furnaces
- Hg from e.g. coke plants and electric arc furnaces

The possibilities of reducing the amounts of Hg and Cd in scrap should be investigated.

TABLE A 3.6 SUMMARY OF EFFLUENT REQUIREMENTS (SWEDEN) (mg/L)

Parameter	(WSPS)	1995
TSS	5.0	20.0
Oil		
Phenol	1.0	0.05
Ammonia	100.0	
Cyanide	1.0	1.0 (total)
Chromium	-	
Lead	(0.2)	(0.2)
Zinc	(0.5)	(0.5)
PAH	-	0.2

( ) Maximum values

A 4.0 GERMANY

A 4.1 AIR EMISSIONS

A 4.1.1 General:

The 1986 TA Luft regulations[1] stress the interaction of air quality control - i.e. specific prescriptions for sites and areas with emissions standards for particular pollutants, industries or processes within industries. "Examination of applications for approval of the Construction and Operation of New Facilities" is an important element.

There is an examination of "considerable disadvantages" and "substantial impairments" where hazards to human health are always substantial. In this regard, carcinogenic substances are defined in three classes of increasing severity and their emission rates prescribed.

Topographical, meteorological and hazard factors (heavy metals, sulphur dioxide) are taken into account. Emissions are defined as the air pollutants originating from a facility.

Emissions are indicated as:

a) mass of emitted materials related to the volume

    aa) of waste gas under standard conditions (0°C; 1013 mbar) after subtraction of water vapour content.

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[1] First General Administrative Regulation Pertaining to the Federal Immission Control Law (Tech Instructions on Air Quality Control - TA Luft), 27 February 1986 (GMBI. p. 95, 202)

bb) of waste (f) gas under standard conditions (0°C; 1013 mbar) after subtraction of water vapour content as mass concentration in the units g/m^3, or mg/m^3.

b) mass of emitted materials related to time as mass flow in the units kg/h, g/h or mg/h;

Mass flow is the total emission occurring for one hour of due operation of a facility under operating conditions which are most unfavourable to the maintenance of air quality.

c) ratio of emitted materials to the mass of products generated or processed (emission factors) as mass ratio in the units of kg/t or g/t.

Waste gases as defined in these instructions are carrier gases containing solid, liquid or gaseous emissions.

The quantities of air which are fed to a system in order to dilute or cool the waste gas shall not be considered when determining mass concentration.

Emission ratio is defined as the ratio of mass of an air polluting substance emitted in the waste gas to the mass supplied with fuels and charge materials; it is given as a percentage.

The relationship between standards and emission limits for a particular facility is clearly given.

The letter of approval (or supplementary directives) will contain:

(a) approved mass ratios
(b) approved emission ratios
(c) approved mass flows

(d) approved mass concentrations of air pollutants in the waste gas -
   - i) all daily means shall not exceed the established mass concentration;
   - ii) 97% of all half-hourly means shall not exceed 6/5 of the established mass concentration;
   - iii) all half-hourly means shall not be more than twice the established mass concentrations.

A 4.1.2 Carcinogenic Substances: (TA Luft Section 2.3)

The specified carcinogenic substances are cited in the following tables. Notably the PAH, i.e. benz[a]pyrene, are considered to be more hazardous than benzene as carcinogens on a mass basis. (The molecular weight of PAH are are 4-8 times greater than benzene). Importantly, polyhalogenated dibenzodioxins, dibenzofurans and PCBs are left to special processing procedures (i.e. site specific) in addition to waste gas purification. Significant factors are:

(1) the concept of initial loading (the immission or impingement of gases or particles prior to construction);
(2) the concept of additional loading from the facilities;
(3) the resultant disadvantages or impairments.

The emissions of carcinogenic substances which are contained in the waste gas shall be limited to the largest possible extent by giving consideration to the principle of proportion.

The carcinogenic materials listed in the following tables must not exceed the concentrations shown. In the event of the presence of substances of several classes, the following shall apply:

> If substances of classes I and II coincide, the mass concentration in the waste gas must not exceed a total of 1 mg/m^3; if substances of classes I and III or classes II and III coincide, the mass concentration in the waste gas must not exceed a total of 5 mg/m^3.

TABLE A 4.1.1 EMISSION STANDARDS FOR CARCINOGENIC SUBSTANCES (WEST GERMANY) - CLASS I

- Asbestos (chrysotile, crocidolite, amosite, anthophyllite, actionlite, tremolite) as fine dust
- Benzo(a)pyrene
- Beryllium and its compounds in respirable form, - indicated as Be -
- Dibenz(a,h)anthracen
- 2-Naphtalamine

At a mass flow of 0.5 g/h or more:
concentration is not to exceed 0.1 mg/m^3

TABLE A 4.1.2 EMISSION STANDARDS FOR CARCINOGENIC SUBSTANCES (WEST GERMANY) - CLASS II

- Arsenic trioxide and arsenic pentoxide, arsenious acid and its salts, arsenic acids and its salts (in respirable form), - indicated as As -
- Chromium (VI) compounds (in respirable form), as far as calcium chromate, chromium (III) chromate, strontium chromate and zinc chromate, - indicated as Cr -
- Cobalt (in form of respirable dusts/aerosols of cobalt metal and cobalt salts of low solubility) - indicated as Co -
- 3,3'-Dichlorobenzinde
- Dimethyl sulfate
- Ethyleneimine
- Nickel (in form of respirable dusts/aerosols of nickel metal, nickel sulfide, and pyritiferous ores, nickel oxide and nickel carbonate, nickel tetracarbonyl), - indicated as Ni -

At a mass flow of 5 g/h or more:
concentration is not to exceed 1 mg/m^3

TABLE A 4.1.3 EMISSION STANDARDS FOR CARCINOGENIC SUBSTANCES (WEST GERMANY) - CLASS III

- Acrylonitril
- Benzene
- 1,3-Butadiene
- 1-Chloro-2,3-epoxipropane (epichlorohydrin)
- 1,2-Dibromomethane
- 1,2-Epoxipropane
- Ethylene oxide
- Hydrazine
- Vinyl chloride

At a mass flow of 25 g/h or more:
concentration is not to exceed 5 mg/m^3

A 4.1.3 General Emission Standards (TA Luft Section 3)

The basic approach is "present state of technology" with an emphasis on minimizing or reducing mass concentrations and emission ratios.

Notably the following factors are cited:

(i) Reducing the amount of waste gas, including the concept of recirculation (within occupational health and safety guidelines) and "encapsulation of installation parts," i.e. reduction of fugitive emissions.

TABLE A 4.1.5 (continued) **INORGANIC DUST PARTICLES EMISSION LIMITS** (West Germany TA Luft Section 3.1.4)

Class III

Antimony	and its compounds, indicated as Sb
Lead	and its compounds, indicated as Pb
Chromium	and its compounds, indicated as Cr
Cyanides	easily soluble (e.g. NaCN), indicated as CN
Fluorides	easily soluble (e.g. NaF), indicated as F
Copper	and its compounds, indicated as Cu
Manganese	and its compounds, indicated as Mn
Platinum	and its compounds, indicated as Pt
Palladium	and its compounds, indicated as Pd
Rhodium	and its compounds, indicated as Rh
Vanadium	and its compounds, indicated as V
Tin	and its compounds, indicated as Sn

at a mass flow rate of 25 g/h or more
not to exceed 5 mg/m^3

NOTE: If substances of several classes are present, the mass concentration in the waste gas shall not exceed a total of 1 mg/m^3 for coinciding Class I and II substances as well as a total of 5 mg/m^3 for coinciding class I and III or class II and III substances.

(ii) Optimizing processes to obtain complete use of resources and energy.

(iii) Optimizing start up, shut down and "special operational states" (process conditions).

The limits for dust emissions are shown in Table A 4.1.4 and for inorganic dust particles in Table A 4.1.5.

TABLE A 4.1.4 **TOTAL DUST EMISSION LIMITS** (West Germany TA Luft Section 3.1.3))

Mass concentrations not to exceed at a mass flow of more than 0.5 kg/h	50 mg/m^3
Mass concentrations not to exceed at a mass flow of up to 0.5 kg/h	0.15 g/m^3

TABLE A 4.1.5 **INORGANIC DUST PARTICLES EMISSION LIMITS** (West Germany TA Luft Section 3.1.4)

Class I		
Cadmium	and its compounds, indicated as Cd	
Mercury	and its compounds, indicated as Hg	
Thallium	and its compounds, indicated as Tl	
at a mass flow rate of 1 g/h or more not to exceed		0.2 mg/m^3
Class II		
Arsenic	and its compounds, indicated as As	
Cobalt	and its compounds, indicated as Co	
Nickel	and its compounds, indicated as Ni	
Selenium	and its compounds, indicated as Se	
Tellurium	and its compounds, indicated as Te	
at a mass flow rate of 5 g/h or more not to exceed		1 mg/m^3

TABLE A 4.1.6 **VAPOROUS OR GASEOUS INORGANIC SUBSTANCES** EMISSION LIMITS (West Germany TA Luft Section 3.1.6)

Class I

Arsine
Cyanogen chloride
Phosgene
Hydrogen phosphide

at a mass flow rate of 10 g/h or more
not to exceed 1 mg/m^3

Class II

Bromine and its vapourous or gaseous compounds, indicated as hydrogen bromide
Chlorine
Hydrocyanic acid
Fluorine and its vaporous or gaseous compounds, indicated as hydrofluoride acid
Hydrogen sulfide

at a mass flow rate of 50 g/h or more
not to exceed 5 mg/m^3

Class III

Vaporous or gaseous inorganic chlorine compounds, if not in Class I, indicated as hydrochloric acid

at a mass flow rate of 0.3 kg/h or more
not to exceed 30 mg/m^3

Class IV

Sulfur oxide (sulfur dioxide and sulfur trioxide) indicated as sulfur dioxide
Nitrogen oxide (nitrogen monoxide and nitrogen dioxide) indicated as nitrogen dioxide

at a mass flow rate of 5 kg/h or more
not to exceed 0.50 g/m^3

TABLE A 4.1.7 **ORGANIC SUBSTANCES EMISSION LIMITS (West Germany TA Luft Section 3.1.7)**

Organic substances, which are broken down into Classes I through III (TA Luft Annex E), shall not exceed the following mass concentrations, even if several substances of the same class are present.

Class I

1,2-Dichlorobenzene
1,4-Dioxan
Toulene
Phenol
and others

at a mass flow rate of	0.1 kg/h or more not to exceed	20 mg/m^3

Class II

1,4-Dichlorobenzene
Xylenes
Carbon disulfide
Naphthaline
and others

at a mass flow rate of	2 kg/h or more not to exceed	0.10 g/m^3

Class III

Dichloromethane
and others

at a mass flow rate of	3 kg/h or more not to exceed	0.15 g/m^3

NOTE: If organic substances in several classes are present, mass concentration in the waste gas shall, in addition to Class I, not exceed a total of 0.15 g/m^3 at a total mass flow of 3 kg/h or more.

A 4.1.4 **Monitoring** (TA Luft Section 3.2.3)

Continuous monitoring is required for:

(a)	Particulate	2-5 kg/h - waste gas opacity >5 kg/h - emission mass concentrations
(b)	SO_2	>50 kg/h - mass concentration
(c)	NO_2 + NO (as NO_2)	>30 kg/h - mass concentration
(d)	Inorganic chlorine	>3 kg/h - mass concentration
(e)	Fluoride	>0.5 kg/h - mass concentration

A 4.1.5 **Specific Requirements for Steel Plant Processes - Air Emissions** (TA Luft Section 3.3)

(a) Furnaces using Coke Oven and Blast Furnace Gases (Steel Production Emission Values) (TA Luft Section 3.3.1.2.3)

Particulate	50 mg/Nm^3
CO	100 mg/Nm^3
NO_2 (indicating NO and NO_2)	200 mg/Nm^3
SO_2 (a) Coke oven gas or refinery gas	100 mg/Nm^3
(b) Mixed coke oven and blast furnace gas (as per Figure 3 in TA Luft)	
100% blast furnace gas	200 mg/Nm^3
50% blast furnace gas and 50% coke oven gas	610 mg/Nm^3
100% coke oven gas	800 mg/Nm^3

(Note that there is an apparent discrepancy between a) and b) for SO_2 emission limits).

(b) Facilities for the Dry Distillation of Hard Coal (Coking Plants) (TA Luft Section 3.3.1.11.1)

Furnaces heated from below

a) Reference value

Emission values for furnace wastes are referenced to a volume content of oxygen in the waste gas of 5 percent.

b) Fuel

Mass concentration of sulfur compounds in the undergrate gas, indicated as sulfur, shall not exceed 0.80 g/m^3.

c) Nitrogen oxides

During the initial measurement nitrogen monoxide and nitrogen dioxide emissions, indicated as nitrogen dioxide, in the waste gas of furnaces heated from below shall not exceed 0.50 g/m^3. All possibilities of improved combustion or other technical measures shall be applied in order to reduce high emissions by aging.

Charging the coke ovens

Particle emissions shall be avoided when drawing off coal from the bunker into the lorries.

Filling gases are to be collected.

During the bulk feeding operations filling gases shall be fed into the crude gas or an adjacent oven as far as this is possible with respect to the follow-on processing of the crude tar.

During compacting the filling gases are to be passed on to the crude gas as feasible.

Filling gases which may not be passed on shall be burned. Particle emissions in the combustion waste gas shall not exceed 25 mg/m^3.

When grading the coal, filling gases shall be prevented by sealing of the grading opening.

Filling Hole Lids

Emissions at filling hole lids shall be avoided as far as possible, e.g. by using filling hole lids with large sealing surfaces, by packing the filling hole lids after each charging of the oven and by regular cleaning of filling hole frames and filling hole lids before closing the filling holes. Oven ceilings shall be freed from coal residues regularly.

Riser Pipe Lids

Riser pipe lids shall be equipped with water dip tanks or adequate systems in order to avoid gas or tar emissions. Riser pipes shall be cleaned regularly.

Coke Oven Operating Machinery

The machinery for operating the coke oven shall be equipped with systems for cleaning the sealing surfaces on the coke oven door frames.

Coke Oven Doors

Coke oven doors with highly effective sealing shall be used, e.g. diaphragm doors or doors of equal sealing efficiency.

The sealing surfaces of the oven doors shall be cleaned regularly. Coke oven groups shall be designed in a manner that allows the installation of door suction systems with dedusters on the machine side as well as on the coke side.

Coke Pushing

Waste gases shall be collected during coke pushing operations and fed to a deduster. Dust imissions shall not exceed 5 g per tonne of coke.

Coke Cooling

Low-emission procedures shall be applied for coke cooling, e.g. dry coke cooling. Dust emissions in the waste gas of the dry coke cooling shall not exceed 20 mg/m^3.

Operating Manual

The measures for emission abatement in coke oven operations shall be established in an operating manual to guarantee properly sealed openings, to ensure that only completely roasted coke is pushed out and to avoid the escape of unburned gases into the atmosphere.

Coking By-product Plants

The requirements for facilities for the production of sulfur (TA Luft Section 3.3.4.1 d.2) shall apply accordingly.

- Sulfur Emission Factor

  a) For Claus systems with a sulfur production capacity of up to 20 tonnes per day, a sulfur emission factor of 3 percent shall not be exceeded.

  b) For Claus systems with a sulfur production capacity of between 20 and 50 tonnes per day, a sulfur emission factor of 2 percent shall not be exceeded.

  c) For Claus systems with a sulfur production capacity of more than 50 tonnes per day, a sulfur emission factor of 0.5 percent shall not be exceeded.

- Hydrogen Sulfide

  The waste gases shall be fed through an after-burning system. Hydrogen sulfide emissions in the waste gas shall not exceed 10 mg/m^3.

The requirements for mineral-oil refineries with respect to storage (TA Luft Section 3.3.4.1 d.2) shall apply accordingly.

Existing Facilities

Facilities already equipped with quenching towers for wet coke cooling shall be converted to low-emission cooling procedures during their basic renewal.

Iron Ore Sintering Plants: (TA Luft Section 3.3.3.1.1)

Particle

Particle containing waste gases shall be collected and fed to a deduster.

The **total dust** and **inorganic dust particle** requirements shall not apply during standstills of the sintering belt caused by malfunctions. However, the deduster shall be operated with maximum separation power.

Nitrogen Oxides

Nitrogen monoxide and nitrogen dioxide emissions, indicated as nitrogen dioxide, in the waste gas shall not exceed 0.40 g/m^3.

Facilities for Producing Pig Iron: (TA Luft Section 3.3.3.2.1)

Particle

Particle containing waste gases, particularly from burdening, emission sources in the blast furnace pouring bay and pig iron desulfurization, shall be collected and fed to a deduster.

Facilities for Producing Steel in Converters, Electric Arc Furnaces and Vacuum Melting Systems; Facilities for Smelting Steel or Cast Iron: (TA Luft Section 3.3.3.3.1)

Particle

a) Particle containing waste gases shall be collected as far as possible and fed to a deduster if this is necessary to meet other requirements.

Chlorine

Chlorine emissions in waste gases caused by refining (chloridization) shall not exceed 3 mg/m^3.

Organic Substances

Emissions of organic substances in the waste gas, indicated as total carbon, shall not exceed 50 mg/m^3.

APPENDIX B

MODEL POLLUTION CONTROL STRATEGY

for

DEVELOPMENT OF POLLUTION CONTROL CRITERIA

B-1 Model Pollution Control Strategy

MODEL POLLUTION CONTROL STRATEGY

for

DEVELOPMENT OF POLLUTION CONTROL CRITERIA

The development of the model pollution control strategy is based on the following concepts:

(1) The development of a model production process and material balance using the most advanced process technology in operating steel plants that has been identified. This will be used as a basis for mass pollutant discharge criteria and in no way prescribes the production processes or material balance that is to be used to meet the pollution control criteria.

(2) The selection of the best available control technology to determine pollutant discharge concentrations and process mass for the pollution control criteria.

(3) The assessment of the above process and control technologies for their impact and effectiveness in reducing the pollutant discharges, including the assessment of their combined pollutant discharges, wastewater, air emissions and waste materials.

(4) The selection of LAER technologies for those pollutants considered to be toxic.

Wastewater:

The determination of the environmental control criteria for wastewater will be based on the following:

(1) **Concept definitions:**

(a) **Process wastewater** - that water that comes into direct contact with process materials, products or by-products or is contaminated by extraneous materials such as oil or grease leakages.

(b) **Process run-off wastewater** - the run-off water originating from precipitation that falls on any part of the production facilities, including buildings and process equipment located outdoors, material storage areas, plant roadways that are associated with production operations and a 20-metre zone surrounding the production process and material storage areas.

(c) **Cooling water** - the water used for indirect cooling of equipment, products, by-products and other materials, not coming in contact with any material that would pollute the water. There may be a blowdown from a cooling tower used to cool the cooling water.

(d) **Storm run-off water** - the run-off water originating from precipitation that falls on areas of the plant other than those specified above.

(2) The model process used for wastewater treatment is a sequential integrated treatment system and follows the concepts of:

(a) Process wastewater generation should be minimized through the selection of the most water-efficient production process and maximum recycle of water whether cooling or process.

(b) Process wastewater should have primary treatment as close to the process source as possible. Where the process wastewater quantities are small, similar process wastewater streams may be combined before primary treatment.

(c) Wastewater pollution control guidelines were developed for each unit process primary treatment plant.

(d) The pollution control guidelines developed for the unit process treatment plants were based on the best available control technology identified. The EPA New Source Performance Standards (NSPS) were used as the basis for these pollution control guidelines. The guidelines were modified on the basis of more recent information including permit requirements and available monitoring data.

(e) The characteristics of the wastewater treated in the blowdown treatment plant were determined by an analysis of the pollution control guidelines developed for the unit process treatment plants.

(f) The pollution control criteria developed for the blowdown treatment plant were based on the best available control technology identified.

Air Emissions:

The pollution control criteria for air emissions were developed on the basis of the best available control technology that was identified. In most cases the control technology that could consistently achieve the lowest emissions was selected. The exceptions were situations where the best available air pollution control technology created significant problems for wastewater treatment and/or solid waste treatment or disposal.

The following concepts were followed:

(a) The collection and control of emissions is located as close to the source as possible to reduce the volume of air or gas that has to be cleaned, thus reducing the size and cost of the facility as well as reducing the energy requirement.

(b) The best available control technology identified by EPA was used as the basis for air pollution control and was modified to reflect recent production process and air pollution control technology advances, requirements of recently issued permits and the available monitoring data.

Solid Waste:

A similar approach was used for solid waste with an emphasis on recycling and meeting the requirements of the British Columbia Special Waste Regulation.

B-2 Steel Plant Model Process and Material Balance

IRON AND STEEL PLANT
MODEL PROCESS AND MATERIAL BALANCE
for
Development of Pollution Control Criteria

The model iron and steel plant process for the development of pollution control criteria is based on the most advanced technologies in commercial use as identified through plant visits, discussions with key experts and review of literature.

The model process is also based on the assumption that the model plant would be built in two stages, the first stage being three million metric tons of liquid steel capacity with the second stage being double that.

In the model process, iron making is based on the use of the conventional blast furnace but incorporates recent technology developments. The raw materials for the blast furnace are considered to be the highest quality currently being used. These include pre-fluxed iron pellets for most of the iron values with the balance being mill scale, pelletized or briquetted blast furnace dust and steel-making slag. The coke rate is based on blast furnaces currently operating with a coke rate of 450 to 460 kg of coke per tonne of iron produced. Based on the operating experience of a number of blast furnaces around the world, 150 kg of this coke is replaced by coal injection. Although higher coal injection rates have been reported for periods of time, the selected coal injection rate is considered to be achievable without encountering serious operating problems.

The model blast furnace process also incorporates high blast temperatures, high top-gas pressure, oxygen enrichment of the blast air and modern process control technology.

Conventional by-product coke ovens are used in the model process incorporating recent technology advances in door design, maintenance techniques, pollution control technology and operating practices. The capacity of the coke oven plant is reduced by about one-third due to the coal injection at the blast furnace.

A combination blown oxygen furnace (top and bottom blowing) with post-combustion is used in the process model for steel making with 30 percent scrap charge. The process model is based on the use of ladle metallurgy for the final molten steel treatment with continuous casting being used for all semi-finished steel.

The cold-rolling production process is the conventional process using high-speed, multiple-stand mills. The acid pickling process is a hydrochloric acid process with rinse recycling and acid regeneration.

The basic material balance used is based on the above model process, on the output of steel from the basic oxygen furnace and on the process yields indicated in the literature. The material balance for this model process is shown in Table B.1.

TABLE B.1 MODEL PROCESS MATERIAL BALANCE SUMMARY

Material	Material per unit production (kg/tonne iron)	Material per unit production (kg/tonne steel)
Blast furnace charge:		
Pre-reduced pellets (60% iron)	1,572	1,210
Steel-making slag (28% iron)	28	22
Coke	310	239
Coal (injection)	150	116
Steel-making charge:		
Scrap		320
Molten iron		770
Semi-finished steel product:		920

The pollutant discharge factors are calculated on the basis of this model material balance.

APPENDIX C

ANALYSIS OF REGULATION, PERMIT AND DISCHARGE DATA

C-1 Introduction

The EPA proposed wastewater and air emission standards and requirements contained in Section 4 are summarized and compared. Wastewater and air emission requirements have been extracted from various permits issued for steel plant processes and are compared with the monitoring data that have been obtained. In many cases the requirements of permits are stated in such a way that concentration limits and/or process weight limits could not be determined. Therefore the actual permit data are limited as are the monitoring data.

C-1.0 Coke Production

C-1.1 Wastewater

Environmental limits and discharge values of wastewater from coke production were collected from a number of sources and analyzed. The sources included:

Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume II Coke Making Subcategory, EPA 440/1-82/024, May 1982

Federal Register, 40 CFR Ch. 1 (7-1-89 Edition) #420.14 New source performance standards (NSPS) (a) By-product cokemaking--iron and steel

Geneva Steel, Utah,
United States Environmental Protection Agency, Region VIII,
Permit No.: UT-0000361, September 28, 1989

Canadian steel plant test results 1990

The EPA New Source Performance Effluent Standards are shown in Table C-1.1.1. The data from the permit and discharge sources are shown in Table C-1.1.2. These two tables contain data on a limited number of pollutants. More limited data on a much larger number of pollutants are contained in Table C-1.1.3.

TABLE C-1.1.1 EPA COKE-MAKING EFFLUENT STANDARDS

Parameter	Concentration (mg/L) 1982 (1)	Mass Standard (g/tonne Coke) 30-day 1982 (2)	Daily 1989 (3)	30-day 1989 (4)
Model Flow (5)		640 L/tonne		
TSS	140	89.4	172	89.4
Oil & grease	5	3.19 (6)	6.38	....
Ammonia - N	20	12.8	54.3	16.0
Cyanides	5	3.19	6.38	3.51
Phenols	0.03	0.016	0.0638	0.0319
Benzene	0.03	0.019	0.0319	......
Naphthalene	0.03	0.019	0.0319	......
Benzo(a)pyrene	0.03	0.019	0.0319	......
pH	6 to 9		6 to 9	

(1) Values shown are maximum daily concentrations.

(2) 30-day average. Daily maximum values are 1.82 times value for cyanide, 1.93 times for TSS, 2.00 times for phenols and 3.4 times for ammonia-N. Increased loadings not to exceed 39% of the standards are allowed for indirect ammonia recovery systems.

(3) Maximum for any 1 day.

(4) Average of daily values for 30 consecutive days.

(5) 390 L/tonne has been demonstrated.

(6) For oil and grease no monthly average is set. Value shown is daily maximum.

(7) Increased loadings not to exceed 16 percent of the above standards are allowed for by-product coke plants which have wet desulphurization systems but only to the extent that such systems generate an increased effluent volume.

(8) Increased loadings not to exceed 39 percent of the above standards are allowed for by-product coke plants which include indirect ammonia recovery systems but only to the extent that such systems generate an increased effluent volume.

TABLE C-1.1.1 (continued) EPA COKE-MAKING EFFLUENT STANDARDS

References:

(1) and (2)	Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume II Coke Making Subcategory, EPA 440/1-82/024, May 1982 (Achievable concentrations and mass standards)
(3) and (4)	Federal Register, 40 CFR Ch. 1 (7-1-89 Edition) #420.14 New source performance standards (NSPS) (a) By-product cokemaking--iron and steel

TABLE C-1.1.2 COKE-MAKING EFFLUENTS - VARIOUS PERMITTED LIMITS AND DISCHARGE VALUES

Parameter	(1)	(2)	
	30-day average		
	(g/tonne coke)		(mg/L)
Flow (L/tonne)			860
TSS	131	74.4	86.5
Oil & grease	10.9	1.8	2.1
Ammonia - N	16.0	83.4	97.0
Cyanides	3.51	18.4	21.4
Phenols	0.0319	0.046	0.054
Benzene	0.0319(3)	0.073	0.085
Naphthalene	0.0319(3)	0.001	0.0011
Benzo(a)pyrene	0.0319(3)	0.024	0.028

(1) Geneva Steel, Utah, (discharge to lagoon) United States Environmental Protection Agency, Region VIII, Permit No.: UT-0000361, September 28, 1989

(2) Canadian steel plant test results 1990 (discharge to lagoon from biological treatment)

(3) Daily maximum

TABLE C-1.1.3 POLLUTANT LEVELS IN COKE PLANT WASTEWATER

Pollutant	Mean Concentration (ug/L)	Mass Rate (mg/tonne coke) 30-day average
Ethylbenzene	<0.4	<0.0003
Styrene	1.0	0.0009
Toluene	1.5	0.0013
Xylene-o	0.7	0.0006
Xylene-m and p	1.1	0.0009
Acenaphthene	<0.7	<0.0006
5-Nitroacenaphthne	<1.8	<0.0015
Acenaphthylene	23.5	0.020
Anthracene	5.3	0.0046
Benzo(a)anthracen	61.1	0.052
Benzo(b)fluoranthene	38.8	0.033
Benzo(g,h,i)perylene	<0.4	<0.0003
Benzo(k)fluoranthene	38.8	0.033
Camphene	<1.0	<0.0009
1-Chloronaphthalene	<0.8	<0.0007
2-Chloronaphthalene	<0.9	<0.0008
Chrysene	53.1	0.046
Dibenz(a,h)anthracene	<0.4	<0.0003
Fluoranthene	107.4	0.092
Fluorene	<0.4	<0.0003
Indeno(1,2,3-cd)pyrene	3.7	0.0032
Indole	<1.2	<0.001
1-Methyl naphthalene	<2.2	<0.0019
2-Methyl naphthalene	<1.5	<0.0012
Perylene	19.1	0.016
Phenanthrene	9.5	0.0082
Pyrene	83.4	0.072
Benzylbutylphthalate	<0.6	<0.0005
Bis(-2-ethylhexyl)phthalate	4.9	0.0042
Di-n-butylphthalate	<1.1	<0.0009
Di-n-octylphthalate	0.9	0.0010
4-Bromophenyl phenyl ether	<0.4	<0.0003
4-Chlorophenyl phenyl ether	<0.9	<0.0008
Bis(2-chloroisopropyl)ether	<1.5	<0.0012
Bis(2-chloroethyl)ether	<1.8	<0.0014
2,4-Dinitrotoluene	<0.5	<0.0004
2,6-Dinitrotoluene	<0.6	<0.0005
Bis(2-chloroethoxy)methane	<1.3	<0.0011
Diphenylamine	<1.9	<0.0016
N-Nitrosodiphenylamine	<1.9	<0.0016
N-Nitrosodi-n-propylamine	<2.1	<0.0018

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(1) Canadian steel plant test results 1990 (discharge from biological treatment to lagoon)

C-1.2 Air Emissions

The mass emission levels proposed for particulate by the EPA are shown in Table C-1.2.1 and are compared to the emission factors contained in Table 4.1.3.6. The emission requirements proposed by the EPA and various permit requirements are shown in Table C-1.2.2.

TABLE C-1.2.1 COKE PLANT MASS EMISSION RATES

Operation		(g/tonne coke)			
	(1) *	(2)**	(3)**	(4)**	(5)**
Coal crushing and handling		2.0	5.8		
Coal preheating		12.5	12.0		
Charging	0.04	14.0	8.0		
Door leaks	0.57	50			
Lid leaks	0.21	30			
Off-takes	0.39				
Pushing		30	45	10	
Quenching		710	270	125	
Combustion stack		710	100		

* Benzene soluble organics

** Particulates

(1) Coke Oven Emissions from Wet-coal Charged By-product Coke Oven Batteries -- Background Information for Proposed Standards, Draft EIS, EPA-450/3-85-028a, April 1987

(2) Handbook of Air Pollution Control Technology, John Wiley & Sons 1984

(3) Compilation of Air Pollutant Emission Factors Volume 1: Stationary Point and Area Sources, Fourth Edition, Supplement B, AP-42, September 1988

(4) Permit Requirements, Struthers Corporation, Brown's Island. Weirton, West Virginia; West Virginia Air Pollution Control Commission, March 20, 1989

TABLE C-1.2.2 **AIR POLLUTION CONTROL REQUIREMENTS FOR BY-PRODUCT COKE OVENS - EPA PROPOSED STANDARDS AND PERMIT REQUIREMENTS**

Parameter		(1)	(2)	(3)	(4)
Larry car charging	(sec/charge)	16	19.3	11	11
Door leaks	(% doors)	10	10	5	5
Lid leaks	(% lids)	3	2	1	1
Off-take leaks	(% off-take)	6	5	4	4
Collector main leaks	(% connections)		0	0	0
Pushing					
(particulate)	(mg/Nm^3)		23	46	
(particulate)	(mg/tonne)			20	10
Combustion stack					
Particulate	(mg/Nm^3) (5)		69	35	
Sulphur oxides	(mg/tonne)				18
Nitrogen oxides	(mg/tonne)				440
Carbon monoxide	(mg/tonne)				85
Quench car	(% opacity)		<20	<10	<10

(1) National Emission Standards for Hazardous Air Pollutants; Coke Oven Emissions From Wet-Coal Charged By-Product Coke Oven Batteries; Proposed Rule and Notice of Public Hearing Federal Register, 40 CFR Part 61, April 23, 1987

(2) U.S. Steel, Geneva Utah works; State of Utah, Department of Health, Consent Decree/Approval Order Limitations

(3) USX Corporation, Clairton. PA; Allegheny County Air Pollution Control Department

(4) Permit Requirements, Struthers Corporation, Brown's Island. Weirton, West Virginia; West Virginia Air Pollution Control Commission, March 20, 1989

(5) Allegheny County particulate emission limit - 30 mg/Nm^3

C-2.0 Iron Production (Blast Furnace)

C-2.1 Wastewater

Environmental limits and discharge values of iron-making wastewater were collected from a number of sources and analyzed. The sources included:

> Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume II Ironmaking Subcategory, EPA 440/1-82/024, May 1982
>
> Federal Register, 40 CFR Ch. 1 (7-1-89 Edition) #420.34 New source performance standards (NSPS). (a) Iron blast furnace. SUBPART C
>
> Geneva Steel, Utah,
> United States Environmental Protection Agency, Region VIII,
> Permit No.: UT-0000361, September 28, 1989
>
> Canadian steel plant test results 1990

The EPA New Source Performance Effluent Standards are shown in Table C-2.1.1. The data from the permit and discharge sources are shown in Table C-2.1.2. These tables contain data on a limited number of contaminants.

TABLE C-2.1.1 IRON-MAKING EFFLUENT STANDARDS - EPA NSPS

Parameter	Concentration (mg/L)(1) 1982 (3)	Mass Standard (g/tonne of hot metal)		
		Daily(2) 1982 (3)	Daily(2) 1989 (4)	30-day 1989 (4)
Model Flow:	292 L/tonne			
TSS	40	11.7	11.7	4.38
Oil and Grease			2.92	......
Ammonia (N)	30	8.76	8.76	2.92
Cyanide (T)	2	0.06	0.584	0.292
Phenols (4AAP)	0.2	0.06	0.0584	0.0292
TRC (5)	0.5	0.15	0.146	......
Lead	0.75	0.22	0.263	0.0876
Zinc	0.9	0.26	0.394	0.131
pH, (Units)	6.0 to 9.0			

(1) Daily Maximum Concentrations

(2) Daily Maximum Standards

(3) Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume II Ironmaking Subcategory, EPA 440/1-82/024, May 1982

(4) Federal Register, 40 CFR Ch. 1 (7-1-89 Edition) #420.34 New source performance standards (NSPS). (a) Iron blast furnace. SUBPART C

(5) The standards for total residual chlorine (TRC) shall be applicable only when chlorination of ironmaking wastewaters is practiced.

TABLE C-2.1.2 IRON-MAKING (BLAST FURNACE) EFFLUENTS - VARIOUS PERMITTED LIMITS AND DISCHARGE VALUES

Parameter	(1) one day	(1) 30-day average	(2) 30-day average	(2)
	(g/tonne)			(mg/L)
Flow (L/tonne)			10,750	
TSS	78.2	26	395	36.7
Ammonia - N	8.76	2.92	25	2.31
Cyanides	1.75	0.876	1	0.094
Phenols	0.0584	0.0292	0.035	0.033
Lead	0.263	0.0876		
Zinc	0.394	0.131	8.2	0.76

(1) Geneva Steel, Utah, (process discharge) United States Environmental Protection Agency, Region VIII, Permit No.: UT-0000361, September 28, 1989

(2) Canadian steel plant test results 1990 (discharge from clarifier)

C-2.2 Air Emissions

The controlled emission factors compared to permit and other data for the blast furnace are shown in Table C-2.2.1.

TABLE C-2.2.1 CONTROLLED PARTICULATE EMISSION FACTORS FOR BLAST FURNACE OPERATION

Source or operation	(1)	(2)	(3)
	Process weight (kg/tonne hot metal)		
Cast house	0.021		20% opacity 3 min./hr.
Slag pouring	0.007		20% opacity 6 min. avg.
Slag crushing and screening	0.013		
Hot metal desulphurization		0.0045	1.77 kg/hr. 20% opacity 6 min. avg.

Source: (1) Handbook of Air Pollution Technology, John Wiley & Sons 1984

(2) Compilation of Air Pollutant Emission Factors Volume 1: Stationary Point and Area Sources, Fourth Edition, Supplement B, AP-42, September 1988

(3) Geneva Steel, Utah; State of Utah, Department of Health, Division of Environmental Health, Approval Order Conditions and Consent Decree (received March 13, 1990)

C-3.0 Steel Making (Basic Oxygen Furnace)

C-3.1 Wastewater

Environmental limits and discharge values of steel-making wastewater were collected from a number of sources and analyzed. The sources included:

> Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume III Steelmaking Subcategory, EPA 440/1-82/024, May 1982
>
> Federal Register, 40 CFR Ch. 1 (7-1-89 Edition) #420.34 New source performance standards (NSPS). (b) Basic oxygen furnace steelmaking -- wet-suppressed combustion and (c) Basic oxygen steelmaking -- wet open combustion.
>
> Geneva Steel, Utah,
> United States Environmental Protection Agency, Region VIII,
> Permit No.: UT-0000361, September 28, 1989
>
> Canadian steel plant test results 1990

The EPA New Source Performance Effluent Standards are shown in Table C-3.1.1. The data from the permit and discharge sources are shown in Table C-3.1.2. These tables contain data on a limited number of contaminants.

TABLE C-3.1.1 STEEL-MAKING EFFLUENT STANDARDS - EPA NSPS

Parameter	Concentration (mg/L)(1) 1982 (3)	Mass Standard (g/tonne of steel)		
		Daily(2) 1982 (3)	Daily(2) 1989 (4)	30-day 1989 (4)
WET-SUPPRESSED COMBUSTION				
Model Flow:	209 L/tonne			
pH (units)	6.0 to 9.0			
TSS	70	14.6	14.6	5.22
Lead	0.9	0.188	0.188	0.0626
Zinc	1.35	0.282	0.282	0.0939
WET-OPEN COMBUSTION				
Model flow	460 L/tonne			
pH (units)	6.0 to 9.0			
TSS	70	32.1	32.1	11.5
Lead	0.9	0.413	0.413	0.138
Zinc	1.35	0.620	0.620	0.207

(1) Daily Maximum Concentrations

(2) Daily Maximum Standards

(3) Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume III Steelmaking Subcategory, EPA 440/1-82/024, May 1982

(4) Federal Register, 40 CFR Ch. 1 (7-1-89 Edition) #420.34 New source performance standards (NSPS). (b) Basic oxygen furnace steelmaking -- wet-suppressed combustion and (c) Basic oxygen steelmaking -- wet open combustion.

TABLE C-3.1.2 STEEL-MAKING (BASIC OXYGEN FURNACE) EFFLUENTS - VARIOUS PERMITTED LIMITS AND DISCHARGE VALUES

Parameter	(1) one-day	(1) 30-day average	(2) 30-day average	(2) (mg/L)
	(g/tonne)			
Flow (L/tonne)			8,380	
TSS	68.7	22.9	320	38.4
Oil and grease			15	1.74
Lead	0.413	0.138	0.23	0.028
Zinc	0.620	0.207	1.9	0.229

(1) Geneva Steel, Utah, (process discharge) United States Environmental Protection Agency, Region VIII, Permit No.: UT-0000361, September 28, 1989

(2) Canadian steel plant test results 1990 (discharge from clarifier)

C-3.2 Air Emissions

The controlled emission factors compared to permit and other data for the basic oxygen furnace are shown in Table C-3.2.1.

TABLE C-3.2.1 CONTROLLED PARTICULATE EMISSION FACTORS FOR BASIC OXYGEN FURNACE OPERATION

Source or operation	(1)	(2)	(3)	(1)	(4)
	Concentration (mg/Nm^3)			Process weight (kg/tonne steel)	
Melting & refining					
Top blown					
Open hood	30	55	50	0.02	0.045
Closed hood	30	55	50	0.0034	
Bottom blown	30	55	50	0.028	
Combination blown					
Closed hood	30	55	50		0.004e
Charging	20		23	0.04 (4)	0.0003
Tapping	20		23	0.0013	
Slagging	20		23	0.005	
Hot metal transfer	20		23	0.0035	
Slag crushing & screening				0.005	

Source: (1) Handbook of Air Pollution Technology, John Wiley & Sons, 1984

(2) Philipp, Dr.-Ing. Jurgen; Thyssen Stahlag Technical Information, Retrofitting of a BOF-steelmaking Shop's Emission Control System, 1983

(3) Federal Register, 40 CFR Ch. 1 (7-1-89 Edition) Subpart N -- Standards of Performance for Primary Emissions from Basic Oxygen Furnaces for Which Construction is Commenced after June 11, 1973

(4) Compilation of Air Pollutant Emission Factors Volume 1: Stationary Point and Area Sources, Fourth Edition, Supplement B, AP-42, September 1988

(4) Emission factor for charging, tapping and sampling

e Estimated

C-4.0 Hot Rolling

C-4.1 Wastewater

Environmental limits and discharge values of hot-rolling wastewater were collected from a number of sources and analyzed. The sources included:

> Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume IV Hot Forming Subcategory, EPA 440/1-82/024, May 1982
>
> Federal Register, 40 CFR Ch. 1 (7-1-89 Edition) #420.54 New source performance standards (NSPS). SUBPART G Hot Forming Subcategory
>
> Geneva Steel, Utah,
> United States Environmental Protection Agency, Region VIII,
> Permit No.: UT-0000361, September 28, 1989
>
> Canadian steel plant test results 1990

The EPA New Source Performance Effluent Standards are shown in Table C-4.1.1. The data from the permit and discharge sources are shown in Table C-4.1.2. These tables contain data on a limited number of contaminants.

TABLE C-4.1.1 HOT-FORMING EFFLUENT STANDARDS - EPA NSPS

Parameter	Concentration (mg/L)(1) 1982 (3)	Mass Standard (g/tonne of steel)		
		Daily(2) 1982 (3)	Daily(2) 1989 (4)	30-day 1989 (4)
PRIMARY WITH SCARFER				
Model Flow:	585 L/tonne			
pH (units)	6.0 to 9.0			
TSS	40	23.4	23.4	8.76
Oil and Grease	40	5.84	5.84	....
SECTION				
Model flow	835 L/tonne			
pH (units)	6.0 to 9.0			
TSS	40	33.4	33.4	12.5
Oil and grease	40	8.34	8.34	......
HOT STRIP & SHEET				
Model flow	1,085 L/tonne			
pH (units)	6.0 to 9.0			
TSS	40	43.5	43.5	16.3
Oil and grease	40	10.9	10.9	.....
PLATE				
Model flow	585 L/tonne			
pH (units)	6.0 to 9.0			
TSS	40	23.4	23.4	8.76
Oil and grease	40	5.84	5.84	......

TABLE C-4.1.1 (continued) **HOT-FORMING EFFLUENT STANDARDS - EPA NSPS**

Parameter	Concentration (mg/L)(1) 1982 (3)	Mass Standard (g/tonne of steel)		
		Daily(2) 1982 (3)	Daily(2) 1989 (4)	30-day 1989 (4)
PIPE AND TUBE MILLS				
Model flow	920 L/tonne			
pH (units)	6.0 to 9.0			
TSS	40	36.9	36.9	13.8
Oil and grease	40	9.17	9.17	......

(1) Daily Maximum Concentrations

(2) Daily Maximum Standards

(3) Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume IV Hot Forming Subcategory, EPA 440/1-82/024, May 1982

(4) Federal Register, 40 CFR Ch. 1 (7-1-89 Edition) #420.54 New source performance standards (NSPS). SUBPART G Hot Forming Subcategory

TABLE C-4.1.2 HOT-ROLLING EFFLUENTS - VARIOUS PERMITTED LIMITS AND DISCHARGE VALUES

Parameter	(1) one-day	(1) 30-day average	(2) 30-day average	(2)
	(g/tonne steel)			(mg/L)
PRIMARY MILL, HOT STRIP MILL AND SCARFER				
Flow (L/tonne)			9,330	
TSS	648	243	380	41.2
Oil and grease	162	.....	44	4.7
Lead			0.09	0.01
Zinc			0.43	0.046
PLATE MILL				
TSS	227	85.1		
PIPE MILL				
TSS	212	79.5		

(1) Geneva Steel, Utah, (process discharge) United States Environmental Protection Agency, Region VIII, Permit No.: UT-0000361, September 28, 1989

(2) Canadian steel plant test results 1990 (discharge from clarifier)

C-4.2 Air Emissions

The controlled emission factors compared to permit and other data for soaking pits and reheat furnaces are shown in Table C-4.2.1.

Table C-4.2.1 AIR EMISSIONS FROM SOAKING PITS AND REHEAT FURNACES

Fuel and control technology	Particulate	SO_x	NO_x
	(kg/tonne steel)		
Fuel oil 1.0% sulphur:			
uncontrolled	0.1 (1)	0.72 (1)	0.62 (2)
controlled - ESP & burner design	0.015 (1)	0.72 (1)	0.35e
Coke oven gas (desulphurized)			
uncontrolled	0.005e	0.004 (2)	0.094 (2)
Controlled - burner design	0.005e	0.004 (2)	0.05e

Sources:		
	(1)	Handbook of Air Pollution Technology, John Wiley & Sons 1984
	(2)	Unpublished data from Canadian steel mill, 1988
	e	Estimated

C-5.0 Cold Forming

C-5.1 Wastewater

Environmental limits and discharge values of cold-forming wastewater were collected from a number of sources and analyzed. The sources included:

> Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume VI Cold Forming Subcategory, EPA 440/1-82/024, May 1982
>
> Federal Register, 40 CFR Ch. 1 (7-1-89 Edition) #420.94, 104, 114, and 124. New source performance standards (NSPS). (b) Hydrochloric acid pickling, (a) Cold rolling mills, alkaline cleaning, and Hot coating.
>
> USS-POSCO Industries, Pittsburg Plant, Contra Costa County, California; Order 88-085 NPDES No. CA0005002, California Water Quality Control Board, San Francisco Bay Region, December 1986
>
> Canadian steel plant test results 1990 (cold mill treatment plant discharge to city sewer)

The EPA New Source Performance Effluent Standards are shown in Table C-5.1.1. The data from the permit and discharge sources are shown in Table C-5.1.2. These tables contain data on a limited number of contaminants.

TABLE C-5.1.1 COLD-FORMING EFFLUENT STANDARDS - EPA NSPS

Parameter	Concentration (mg/L)(1) 1982 (3)	Mass Standard (g/tonne of steel)		
		Daily(2) 1982 (3)	Daily(2) 1989 (4)	30-day 1989 (4)
COLD ROLLING (5)				
Model Flow: 42 L/tonne				
TSS	60	2.50	2.50	1.25
Oil and Grease	25	1.04	1.04	0.417
Lead	0.45	0.019	0.0186	0.0063
Zinc	0.3	0.012	0.0125	0.0042
pH, (Units)	6.0 to 9.0			
HYDROCHLORIC ACID PICKLING				
Model Flow: 167 L/tonne				
TSS	70	11.7	11.7	5.01
Oil and Grease	30	5.0	5.01	1.67
Lead	0.45	0.075	0.0751	0.0250
Zinc	0.3	0.050	0.100	0.0334
pH, (Units)	6.0 to 9.0			
Fume Scrubber (6)				
Model Flow: 57 L/tonne				
TSS	70	5.73	5.72	2.45
Oil and Grease	30	2.46	2.45	0.819
Lead	0.45	0.37	0.0368	0.0123
Zinc	0.3	0.025	0.0491	0.0164
pH, (Units)	6.0 to 9.0			

TABLE C-5.1.1 (continued) COLD-FORMING EFFLUENT STANDARDS - EPA NSPS

Parameter	Concentration (mg/L)(1) 1982 (3)	Mass Standard (g/tonne of steel)		
		Daily(2) 1982 (3)	Daily(2) 1989 (4)	30-day 1989 (4)
ALKALINE CLEANING				
Model Flow: 209 L/tonne				
TSS	70	14.6	14.6	6.26
Oil and Grease	30	6.3	6.26	2.09
pH, (Units)	6.0 to 9.0			
HOT COATING				
Model Flow: 677 L/tonne				
TSS	70	44	43.8	18.8
Oil and Grease	30	18.8	18.8	6.26
Hexavelant Chromium	0.06	0.038	0.0376	0.0125
Lead	0.45	0.282	0.282	0.0939
Zinc	0.3	0.188	0.376	0.125
pH, (Units)	6.0 to 9.0			
Fume Scrubber (6)				
Model Flow: 57 L/tonne				
TSS	70	5.72	5.72	2.45
Oil and Grease	30	2.45	2.45	0.819
Hexavelant Chromium	0.06	0.0049	0.0049	0.00163
Lead	0.45	0.0368	0.0368	0.0123
Zinc	0.3	0.0245	0.0491	0.0164
pH, (Units)	6.0 to 9.0			

TABLE C-5.1.1 (continued) COLD-FORMING EFFLUENT STANDARDS - EPA NSPS

Parameter	Concentration (mg/L)(1) 1982 (3)	Mass Standard (g/tonne of steel)		
		Daily(2) 1982 (3)	Daily(2) 1989 (4)	30-day 1989 (4)

(1) Daily Maximum Concentrations

(2) Daily Maximum Standards

(5) Multi-stand

(6) kg/day added to process limit

Sources: (3) Development Document for Effluent Limitations Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category Volume VI Cold Forming Subcategory, EPA 440/1-82/024, May 1982

(4) Federal Register, 40 CFR Ch. 1 (7-1-89 Edition) #420. New source performance standards (NSPS).

TABLE C-5.1.2 **COLD-FORMING EFFLUENTS - VARIOUS PERMITTED LIMITS AND DISCHARGE VALUES**

Parameter	(1)	(2)	(2)
	30-day average (g/tonne steel)		(mg/L)
Flow (L/tonne)		750	
ACID PICKLING			
TSS	35		
Oil and grease	11.7		
Lead	0.175		
Zinc	0.234		
COLD FORMING			
TSS	37.6	374	498
Oil and grease	12.5	39	52.2
Lead	0.188	0.06	80
Zinc	0.125	0.22	300
ALKALINE CLEAN			
TSS	43.8		
Oil and grease	14.6		
GALVANIZING			
TSS	75.1		
Oil and grease	25		
Lead	0.376		
Zinc	0.5		

TABLE C-5.1.2 (continued) COLD-FORMING EFFLUENTS - VARIOUS PERMITTED LIMITS AND DISCHARGE VALUES

Parameter	(1)	(2) 30-day average (g/tonne steel)	(2) (mg/L)
ACID PICKLING			
Fume scrubber (3)			
TSS	5.39		
Oil and grease	1.80		
Lead	0.03		
Zinc	0.04		
GALVANIZING			
Fume scrubber (3)			
TSS	35.9		
Oil and grease	12.0		
Lead	0.14		
Zinc	0.24		

(1) USS-POSCO Industries, Pittsburg Plant, Contra Costa County, California; Order 88-085 NPDES No. CA0005002, California Water Quality Control Board, San Francisco Bay Region, December 1986

(2) Canadian steel plant test results 1990 (discharge from cold mill treatment plant serving cold rolling, pickling, alkaline cleaning, hot coating and electrolytic coating).

(3) Kg per day maximum added to process limits.

C-5.2 Air Emissions

The controlled emission factors compared to permit and other data for cold forming are shown in Table C-5.2.1.

C-5.2.1 CONTROLLED EMISSION FACTORS FOR COLD-FORMING OPERATION

Source or operation	Pollutant	Technology	(1) Process weight (kg/tonne steel)	(2) Process weight (kg/tonne steel)	(2) Concentration (mg/Nm^3)
HCl Pickle Line	Partic.	Packed bed scrubber	0.001	0.002	20
	HCl			0.001	10
Cold-rolling mill	Partic.	Mist eliminator	0.06		13
Annealing	NO$_x$	Low-NO$_x$ burner			200

Source: (1) NUCOR Steel, Crawfordsville, Indiana; Indiana Department of Environmental Management, Office of Air Management, Construction Permit No. PC (54) 1742, April 28, 1989

(2) Various sources, Section 4.4

APPENDIX D

GLOSSARY

Acid regeneration	Process by which spent pickle liquor is converted into acid for reuse and iron oxide by-product.
Agglomeration	Process by which fine materials (e.g. iron ore, flue dust) are bound together using a binder such as bentonite and thermal treatment. See sintering, briquetting, pelletizing.
Air flotation	Process in which gas bubbles, usually air, are released in the wastewater and attach to floatable materials, such as oil, causing them to float more rapidly to the surface from where they are skimmed off as a froth.
Alkaline cleaning	Method of cleaning the surface of steel where mineral and animal fats and oils must be removed. Pressurized spray application of alkaline solutions of cleaners (caustic soda, soda ash, alkaline silicates, phosphates) is usually the selected method.
Alloy steel	Those steels which owe their enhanced properties to the presence of one or more special elements or to the presence of larger proportions of elements, such as manganese and silicon, than are ordinarily present in carbon steel.
Ammonia still	Special still used in the coke oven by-product plant to remove ammonia from weak ammonia liquor.
Annealing	Controlled heating of steel to relieve cooling stresses induced by cold or hot working and to soften the steel to improve its machinability or formability.
Argon-oxygen decarburization (AOD)	Process whereby carbon is removed from steel, usually alloy steel, in a furnace or ladle by bubbling a mixture of argon and oxygen through the molten steel.

BACT (Best Available Control Technology)	A definition of control technology used in setting emission limitations (air, water or waste) based on the maximum degree of reduction of each pollutant taking into account energy, environmental impacts, economic impacts and other costs. Used by EPA in the development of emission and effluent standards. See introduction in Section 1.0 for Ministry of Environment of British Columbia definition.
Bar mill	Hot-rolling mill used to produce bar shapes, such as rounds, flats, hexagonals or squares.
Basic oxygen furnace (BOF)	A refractory-lined vessel used to produce steel by the basic oxygen process.
Basic oxygen steel making process (BOP)	Process where oxygen is injected through a special lance into the molten iron to produce steel.
BAT (Best Available Technology)	Former terminology for BACT, which see.
Bath	Pool of material in a process vessel, such as the molten pool of iron and steel in a basic oxygen furnace.
Beneficiation	Process by which impurities are removed from a raw material such as iron ore.
Benzol plant	Used for the recovery of benzol (mixture of benzene, toluene and xylene) from coke oven gas as a by-product.
Billet	Intermediate steel shape produced by hot rolling, usually square or slightly oblong and ranging in size from 50 mm by 50 mm to 125 mm by 125 mm.
Biological treatment	Removal of biologically degradable pollutants from wastewater through the action of micro-organisms.
Blast furnace	Large, vertical, tubular refractory-lined furnace to produce molten iron from iron ore, coke and flux materials.

Blast furnace gas	Waste gas from the blast furnace operation which is cleaned for use as a fuel of low calorific value.
Blast furnace stove	Regenerative type refractory heat exchanger heated by gaseous fuel used to heat blast air for the blast furnace operation.
Bloom	Intermediate steel shape produced by hot rolling, usually square or slightly oblong and ranging in size from 150 mm by 150 mm to 300 mm by 300 mm.
Blowdown	Wastewater side stream from a cooling tower or other recirculating water use that is usually drawn off continuously to prevent excessive build up of contaminants that would make the water unusable for reuse.
Boiler feed water treatment	Water treatment system used to remove impurities and hardness from water prior to use to make steam in a boiler.
Bottom-blown oxygen steel making process (Q-BOP)	Process where oxygen is injected into the molten iron through special tuyeres in the bottom of the furnace to produce steel.
Briquetting	Agglomeration of fine material, such as iron ore fines, with a binder in a press or roll press.
Burden	Raw material mixture of iron ore (lump ore, pellets or sinter), flux and coke introduced into the blast furnace to produce iron.
Carbon steel	Those steels that contain carbon, up to 0.60% silicon, 1.65% manganese and 0.60% copper in addition to much smaller amounts of other elements, such as sulphur and phosphorus. Carbon steels represent the most important group of engineering products known and the major percentage of steel production.

Cascade rinsing	Water rinsing system to remove contaminants from surface of steel where the rinse water is recycled from one rinse tank to the next.
Cast house	Building surrounding lower portion of blast furnace where tapping of the molten iron and slag takes place.
Centrifuge	Material separation device which rotates at high speed forcing the heavy material fraction to the outside of the centrifuge.
Clarifier	Material separation device which separates particulate material from wastewater by gravity settling and discharges the settled material as a slurry.
Clarifier underflow	Discharge of concentrated wastewater from clarifier containing majority of pollutants.
Claus process	Process to remove hydrogen sulphide from a gas by oxidation to sulphur.
Coal injection	Process to inject coal into the blast furnace through the tuyeres with the hot blast to replace coke in the burden.
Coke	Product produced by the distillation of coal in the absence of air, used for the production of iron in a blast furnace.
Coke battery	That part of the coke oven plant used to produce coke from coal. Consists of 30 to 100 coke ovens.
Coke breeze	Fine fraction of coke recovered from screening the quenched coke.
Coke by-product plant	Section of the coke oven plant that processes the coke oven gas and recovers by-products.
Coke oven	Refractory-lined, rectangular chamber used to produce coke from coal which is heated by circulating hot gas in flues built into the walls of each oven.

Coke oven gas	Waste gas generated in the production of coke from coal, processed and cleaned in the by-product plant to produce a gaseous fuel for plant use.
Coke pushing	Removal of the hot coke from the coke oven by pushing the coke at one end with a ram thus forcing the coke to exit from the other end of the coke oven into the quench car.
Coke quenching	Quenching of the hot coke after discharge from the coke oven to cool the coke, usually by water sprays in a quench tower, sometimes by cooled recirculating gas in an enclosed container.
Cold rolling	Forming the steel while cold by passing it through a cold-rolling mill.
Collector main	Pipe or pipes on the coke oven battery that collect the coke oven gas from the individual coke ovens and transport the gas to the by-product plant.
Continuous casting	Pouring molten steel from a ladle through a mould to produce a continuous shape such as a slab or billet.
Converter	Another term for the basic oxygen furnace.
Degassing	Removing trace quantities of gases, such as oxygen or nitrogen, from molten steel.
Denitrification	Removing nitrogen from nitrates and other nitrogen-containing compounds in wastewater.
Direct reduction	Process by which the iron ore (iron oxide) is converted to an impure metallic iron using a solid reductant, such as coal, or a gaseous reductant, such as natural gas.
Electric arc furnace (EAF)	Refractory-lined vessel with alternating electric current passing through graphite electrodes from one electrode through the molten steel bath to another electrode, used to produce steel from scrap or pre-reduced iron pellets.

Electrostatic precipitator	Dust collection device for air emissions which uses an electrical field to charge the dust particles thus attracting them to the collector.
Emission factor	Weight of pollutants emitted per tonne of product produced by the production process or per tonne of steel produced by the steel melting shop.
EPA	Environmental Protection Agency of the United States.
EPA New Source Performance Standards	Pollution control criteria developed and included in regulations by EPA for new pollution sources in the United States.
Fabric filter (baghouse)	Dust collection device for air emissions which draws the polluted air or gas stream through a fabric filter, usually in tubular form, similar in principle to the household vacuum cleaner.
Final cooler	Spray-type cooler to reduce the clean coke oven gas temperature to ambient temperature levels.
Flocculant	Chemical added in wastewater treatment that assists small or fine particles to be attracted to each other and settle more rapidly.
Fluidized bed process	Process where sized granular material in a reactor vessel is fluidized through the injection of a fluidizing gas at the base of the reactor. Granular material may be the material that is reacted, such as in direct reduction of iron ore where the fluidizing gas is also the reducing agent, or may be a reaction product as in hydrochloric acid regeneration.
Flushing liquor	Mixture of pollutants in water which has been condensed from the coke oven gas. The flushing liquor is cooled and recirculated as a cooling liquid for the coke oven gas off-takes.

Flux	Material used to render unwanted materials more easily fusible or to combine with such materials to prevent them from combining with the metal in the iron or steel smelting process. Facilitates the removal of such unwanted materials.
Fugitive emissions	Emissions that escape from a manufacturing or other process or from an open area, e.g. dust from vehicular traffic on a dry gravel road.
Fume scrubber	Wet or dry scrubbing device to remove metallic or metal oxide fumes or chemical fumes from an exhaust stream before discharge to the atmosphere.
Galvanizing	Process for the application of a zinc coating to a steel surface for protection from corrosion.
Granulate	Process of agglomeration of fine material into granular shape.
Gravity sedimentation	Process used to remove fine solid material by gravity settling from wastewater.
Heat	Technical name given to a batch of steel produced in the steel-melting furnace (e.g., heat no. xx).
Hood	Enclosure around a piece of process equipment that is used to direct the air pollutants to an exhaust duct for collection.
Hot blast	Heated air blown into the blast furnace through the tuyeres, used to react with the coke as part of the blast furnace smelting process reactions.
Hot coating	Process of coating a steel surface with a molten metal, such as zinc.
Hot metal	Molten iron produced in the blast furnace used as an intermediate material to produce steel.

Hot rolling	Process of reducing the cross sectional area of steel at high temperature by passing the steel between a pair of rolls.
Hot strip	Thin, continuous, flat steel shape, usually less than 6 mm in thickness, produced by hot rolling.
Inclusion	Particle or cluster of particles of foreign material, often non-metallic, remaining in steel which produces a surface or interior defect after forming.
Ingot	Cast steel shape used as an intermediate material between the steel-melting furnace and the hot-forming equipment.
Ingot mould	Cast iron mould used to produce ingots by pouring molten steel into the mould.
Iron pellets	Small ball or pellet of fine iron ore produced by mixing fine iron ore with a binder, such as bentonite, forming into a ball and hardening the ball in a furnace.
Kish	Mixture of fine iron oxide fume and small graphite platelets produced by the cooling of molten iron.
Ladle	Refractory-lined portable vessel used to transport molten iron and steel.
Ladle metallurgy	Process of the final refining and alloying of molten steel in the ladle after tapping from the melting furnace, rather than in the melting furnace.
LAER (Lowest Achievable Emission Rate)	Lowest emissions any source with similar exhaust characteristics has achieved in practice or the most stringent emission criteria applied to similar sources by other competent regulatory agencies.
Lagoon	Pond used to provide short-term storage for treated wastewater to allow chemical reactions to be completed, equalization to take place, some settlement of solids and for emergency storage.

Larry car	Mobile car running on rails on the top of a coke oven battery. Larry car is equipped with coal hoppers for the transport of coal from the coal storage bins to the individual coke oven and for the charging of the coal into the oven.
Light oil	Mixture of benzene, toluene and xylene with impurities collected from the coke oven gas in a coke oven by-product plant.
Luting	Process of sealing openings around doors or lids on a coke oven with a refractory sealant.
Mixed media filter	Filter for removal of solids from wastewater using layers of different filter media.
mg	Milligram, one thousandth of a gram.
mg/L	Milligram per litre is a measure of the pollutant concentration in wastewater.
mg/Nm^3	Milligram per normal cubic meter is a measure of the pollutant concentration in a waste gas stream or in ambient air. Normal condition of the gas is at 20 degrees Centigrade and 760 mm of mercury.
Neutralization	Process of treating an acid or basic solution with chemicals to produce a neutral or nearly neutral solution.
NSPS (New Source Performance Standards)	Emission or effluent standards developed by EPA for application to new industrial pollution sources based on BACT.
Oil emulsion	Liquid mixture of oil and water in which the oil is suspended in minute globules.
Oil skimming	Process of removing oil from the surface of a container of wastewater.
Opacity	The quality of not allowing light to pass through, used as a measure of the amount of particulate material in a waste gas stream.
Particulate	Solid material usually of small size.

Pelletize	Process of agglomerating fine material into a pellet.
Pickling	Process of removing the iron oxide coating from a steel surface by immersing the steel in a bath of acid.
Pig casting	Process of casting molten pig iron into small ingots called pigs.
Pig iron	Solidified iron usually in the form of an ingot called a pig.
Plate	Flat steel shape usually more than 6 mm thick and of varying widths and lengths made by hot rolling.
Pollutant	Waste material that may be discharged to the environment, considered to be detrimental to the environment.
Pollutant criteria	Quantity of pollutant that is allowed to be discharged into the environment, usually measured in weight per unit volume or in some cases weight per unit of production, usually incorporated into a regulation or pollution permit.
Polyelectrolytes	Complex chemical used to enhance the agglomeration of solid particles in wastewater.
Precipitation	Fall of moisture on the earth's surface in the form of rain, snow, etc.
Primary cooler	Used to cool the hot coke oven gas as it leaves the coke oven and condense out some of the vaporous materials.
Quench car	Specially-designed railcar used to catch the hot coke as it leaves the coke oven and transport the hot coke to the quenching operation.
Refining	With respect to steel, refers to the process of removing unwanted impurities from the molten steel.
Reheating furnace	Furnace used to reheat steel between processes, such as ingots or slabs prior to hot rolling.

Rod mill	Hot-rolling mill that produces a small diameter steel rod that is usually used as a starting material to manufacture steel wire.
Rolling	Process of passing a steel shape, either hot or cold, between two rolls to change the shape, such as reducing the thickness of a slab and consequently increasing the length of the slab.
Rolling mill	Structure that contains and drives the rolls for the rolling operation.
Rolling oil	Oil/water emulsion that is used to lubricate the steel passing through the rolls in the cold-rolling operation and to remove some of the heat generated by the rolling operation.
Scale	Iron oxide coating on the surface of steel that forms during a reheating process.
Scale pit	Specially-designed pit that collects the water used in the hot-rolling process and settles out the scale that is removed from the steel surface during the rolling operation.
Scarfing	Removal of a thin layer of steel, including the scale and any surface imperfections, from a steel shape by oxy-fuel jets.
Scrap	Steel that does not perform its original function, such as car hulks, empty cans.
Section mill	Hot-rolling mill that is used to roll structural shapes, such as beams and angles.
Shear	Process of cutting a piece of steel between two blades as in cutting a piece of paper with scissors.
Sheet	Similar to plate but usually less than 6 mm in thickness.
Sinter	Iron ore that has been agglomerated into larger pieces by partial melting.

Slab	Intermediate steel shape produced by hot rolling, always oblong and mostly 50 mm to 230 mm thick and 610 mm to 1520 mm wide.
Slag	Waste material that contains many of the unwanted impurities from the production of molten iron or steel.
Sludge	Waste material that has settled out of wastewater and has been partially de-watered.
Soaking pit	Reheating furnace to heat ingots to rolling temperature.
Soluble salts	Compound containing a metal and a non-metal that is soluble in water.
Spent pickle liquor	Waste acidic solution from the steel pickling operation.
Spray roaster	Furnace used for high-temperature processing of some materials, such as spent pickle liquor, where the material is sprayed into the furnace.
Stretford process	Proprietary process for the removal of hydrogen sulphide from coke oven gas.
Strip	Thin (usually less than 6 mm thick) strip of steel up to 3,000 mm wide of a long length, wound in a coil for transport and processing.
Tapping	Process of removing the molten metal from a blast furnace or steel-melting furnace.
Teeming	Process of pouring the molten steel into ingot moulds for ingots.
Thickener	Device for removing solid material from wastewater by settling (sedimentation), also known as clarifier.
Tonne	Unit of weight - 1,000 kilograms.
Top-blown converter	Melting furnace used in the basic oxygen process of producing steel. Oxygen is blown down on the bath of molten iron through a vertical lance, hence top-blown.

Torpedo ladle car	Specially-designed railroad car with a refractory-lined container similar to a horizontal cylinder used to transport molten iron from the blast furnace to the melt shop.
Tube round	Cylindrical piece of steel that is the starting material to make a hollow steel tube.
Tundish	Refractory-lined vessel that is used as an intermediary vessel for pouring molten steel between the ladle and a mould, such as in continuous casting.
Tuyere	Enclosed tubular opening, such as through the wall of a blast furnace, for the injection of a gas or gases into a high temperature vessel or furnace.
μg	Microgram, one millionth of a gram.
Vacuum degassing	Process of subjecting molten steel to a vacuum to remove unwanted gases.
Vacuum filter	Device to remove water from sludge by subjecting the filter to a vacuum and pulling the water out of the sludge through the filter.
Venturi scrubber	Device using the venturi principle which accelerates the gas stream through a nozzle and then expands the gas causing the particulate material in the gas to drop out.
VOC (volatile organic compounds)	Organic compounds that are volatile at or slightly above atmospheric or room temperatures.
Wash oil	Petroleum distillate oil that is used to dissolve and remove the light oil from the coke oven gas.
Wastewater	Water that has been contaminated with pollutants.
Weak ammonia liquor	Aqueous solution condensed from coke oven gas which contains ammonia.
Yield	Measure of saleable steel product as a percentage of the crude steel produced.